PROCEEDINGS

OF THE

AMERICAN PHILOSOPHICAL SOCIETY

HELD AT PHILADELPHIA

FOR

PROMOTING USEFUL KNOWLEDGE.

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DETROIT, MICH.

Vol. XXIV.

JANUARY TO DECEMBER, 1887.

PHILADELPHIA:
PRINTED FOR THE SOCIETY
BY MAC CALLA & COMPANY.
1887.

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☞ It is requested that the receipt of this number be acknowledged.

☞ In order to secure prompt attention it is requested that all correspondence be addressed simply "To the Secretaries of the American Philosophical Society, 104 S. Fifth St., Philadelphia."

PUBLISHED FOR THE AMERICAN PHILOSOPHICAL SOCIETY

BY

MacCALLA & COMPANY,

NOS. 237-9 DOCK STREET, PHILADELPHIA.

EXTRACT FROM THE BY-LAWS.

CHAPTER XII.

OF THE MAGELLANIC FUND.

SECTION 1. John Hyacinth de Magellan, in London, having in the year 1786 offered to the Society, as a donation, the sum of two hundred guineas, to be by them vested in a secure and permanent fund, to the end that the interest arising therefrom should be annually disposed of in premiums, to be adjudged by them to the author of the best discovery, or most useful invention, relating to Navigation, Astronomy, or Natural Philosophy (mere natural history only excepted); and the Society having accepted of the above donation, they hereby publish the conditions, prescribed by the donor and agreed to by the Society, upon which the said annual premiums will be awarded.

CONDITIONS OF THE MAGELLANIC PREMIUM.

1. The candidate shall send his discovery, invention or improvement, addressed to the President, or one of the Vice-Presidents of the Society, free of postage or other charges; and shall distinguish his performance by some motto, device, or other signature, at his pleasure. Together with his discovery, invention, or improvement, he shall also send a sealed letter containing the same motto, device, or signature, and subscribed with the real name and place of residence of the author.

2. Persons of any nation, sect or denomination whatever, shall be admitted as candidates for this premium.

3. No discovery, invention or improvement shall be entitled to this premium, which hath been already published, or for which the author hath been publicly rewarded elsewhere.

4. The candidate shall communicate his discovery, invention or improvement, either in the English, French, German, or Latin language.

5. All such communications shall be publicly read or exhibited to the Society at some stated meeting, not less than one month previous to the day of adjudication, and shall at all times be open to the inspection of such members as shall desire it. But no member shall carry home with

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Critical Remarks on the Editions of Diego de Landa's Writings.

By Daniel G. Brinton, M.D.

(*Read before the American Philosophical Society, Jan. 7, 1887.*)

No document bearing upon the ancient Maya civilization of Yucatan surpasses in importance the work written by Diego de Landa, the second Bishop of the Diocese of Mérida, who was a resident of Yucatan from 1549 until 1579, the year of his death. The description of the country and its inhabitants which he composed has been preserved to us in one MS. copy, now in the library of the Royal Academy of History, at Madrid. In the winter of 1863–4, the late Abbé Brasseur (de Bourbourg) transcribed a portion of it, and published it with notes, and a translation into French, the following summer, under the title, *Relation des Choses de Yucatan de Diego de Landa, etc.* (Paris. Arthus Bertrand, 1864). As it contained the signs of the calendar, and what purports to be the alphabet of the Maya hieroglyphic writing, as well as much material relating to the customs of the natives, Landa's *Relation* at once took a leading position among Americana.

The well-known peculiarities of the Abbé Brasseur, however, the freedom with which he dealt with his authorities, and the license he allowed his imagination, have always cast an atmosphere of uncertainty about his work,* and hence it was a decided

* This general distrust with reference to the particular instance of the Landa MS. has been very vigorously expressed by Dr. P. J. J. Valentini in his article on the Landa alphabet, in *Proceedings of the American Antiquarian Society* for 1880, p. 91.

satisfaction to have published at Madrid, in 1884, under the competent supervision of Don Juan de Dios de la Rada y Delgado, a literal, faithful copy of the original text. Unfortunately, it appears simply as an appendix to the Spanish translation of M. Leon de Rosny's work on the hieratic writing of Central America, and is issued to the limited number of 200 copies, all large folio. It is therefore both difficult to obtain and needlessly expensive. Moreover, the editor, for fear of "distracting the reader," as he tells us, pointed out only a few of the differences between the correct text and that printed by Brasseur, so that the real value of the second edition of the text is not apparent until a long and toilsome comparison has been made.

The leading position which Landa's *Relacion* holds with reference to the ancient Maya civilization has led me to examine his words with care, and the notes I have made will, I believe, prove of value to those who are engaged in the study of this remarkable people. I shall arrange these notes in three portions, as they refer to the two texts now printed, to the Abbé Brasseur's translation with its notes, and to the hieroglyphic signs, etc., inserted in the text.

The Text.

In Brasseur's edition the text is divided into numbered sections, each with an appropriate heading. No such arrangement is in the original. What is more objectionable, many of the paragraphs and even sections as arranged by Brasseur are entirely arbitrary, and do not correspond at all with the paragraphing of the original. Sometimes they begin in the midst of a phrase, cutting it in two, and destroying its meaning.

He omits, without a word, fully one-sixth of the whole text. In his edition, p. 346, he concludes with the words, *aqui acaba la obra de Landa*, "here closes the work of Landa." No such words are in the original. On the contrary, the MS. he copied from continued with a number of chapters, one on the reason why the Indians offered human sacrifices, others on the serpents, animals, trees, etc., of Yucatan. Of these Brasseur says not a syllable. In copying he occasionally, but rarely, omitted sentences, doubtless through haste. An instance of this occurs, p. 328, where three lines of the original are dropped immediately after the word *escalera*, terminating the sentence.

He did not hesitate occasionally to alter the original when he could not get at its meaning conveniently. Thus, p. 100, he prints "pero que a parte de los españoles," whereas the original is "pero que entre los Españoles," which conveys exactly the opposite sense. Again, p. 162, lines 2, 3, he writes "otras se separavan partes de su cuerpo," where the original is "se sejavan." Oddly enough, in the note on p. 104, he claims to have altered the text from "tres fiestas" to "otras fiestas," whereas the latter alone stands in the original.

The proof-reading of Brasseur's Spanish text leaves something to be desired. On the first page I have noted three errors, *vaya* for *via*, *haz el* for *haz á*, and *hiervas* for *sierras*, which last error he carries into his translation. Others, as *llamaron* for *llevaron*, p. 20, line 1, and *alcangaron* for *alancearon*, p. 76, line 10, are not much misleading.

Of greater moment is his inaccuracy in both the spelling and translation of proper names and Maya words. I shall mention a few of these:

Taiza, p. 4. This is for *tah itza*, "the lord or ruler of the Itzas."

Ulumil Cuz y Etel Ceh, p. 6. These Maya words were understood and translated by Brasseur as two distinct names connected by the copulative conjunction *y*, *et*, *and*. This is not the case. They form one term, the correct spelling of which is *uluumil cutz yetel ceh*, "the land of the wild turkey and deer."

Cuzmil, p. 12. The "Swallow-island," *ah-cuzamil peten*, according to the *Diccionario Maya-Español del Convento de Motul*, *MS.*, was also called *Oycen* and *Oycib*. In these names *cen* means "ornament," and *cib*, "wax," while the prefix *oy* is an interjection.

Maya, p. 14. The form adopted by Brasseur, *Ma-ay-ha*, meaning "there is no water," is incorrect. This phrase in the Yucatecan tongue is *Ma yan ha*. For a more plausible derivation of the word *Maya*, see *The Maya Chronicles*, p. 16 (Philadelphia, 1880, vol. I of Brinton's *Library of Aboriginal American Literature*).

The names of the idols mentioned, p. 16, read in the original *Ixhunié*, and *Ixhunieta*, not *Ixbunié*, etc. The prefix *ix* in all four names is the feminine particle. The meanings are:

Ix-chel, the Lady of the Rainbow, or "of the Cheles."
Ix-chebel-yax, the Lady of the green (blue) feathers.
Ix-hun-yei, the one chosen Lady.
Ix-hun-yeta, the Lady with the one adornment.

Mochcovoh, p. 18. The *Covohes* are referred to, p. 72, as the name of the tribe near Champoton. The word *Covoh* is applied to a poisonous spider found in Yucatan, and here probably has a totemic signification. It is still, says Dr. Berendt, a common family name among the Mayas.

On p. 30, the original has *Cochnah* instead of *Cochuah;* but the latter is probably correct, being a simple compound of *coch*, broad or large, and *uah*, bread or tortilla. *Hocabaihumun* has no terminal *n* in the original. The proper form I expect is *Hoccabal-hunhun*, "cosa asentada en el suelo cada año," referring to the year-stones which were annually set up.

Tikoch, p. 52, orig. *Tiboch*. The former is correct. It means "at (the place of) the castor-oil plants" (*ti*, at, *xkoch* or *koch*, the *Ricinis communis*).

Mai, p. 42. This word means ordinarily snuff, or pulverized tobacco. Brasseur, in his note, derives from it the name Maya, forgetting that on p. 14 he had assigned a different etymology.

Tutulxiu, p. 46. On the derivation of this name see *The Maya Chronicles*, p. 109.

Ɔilan, p. 52. The proper form is *ɔilaan*, and means something filled, realized, perfected, attested, etc.

Chicaca, p. 70. Brasseur says that Cogolludo calls this province *Chavacha-Háa*. This is inaccurate. Cogolludo's words are "Choáca, que los Indios llaman Chuuachaá" (*Hist. de Yucathan*, Lib. II, cap. viii). This is a compound of *chauac*, large, great, and *ha*, water.

Vamuxchel, p. 76. The original has *Namuxchel*. The correct form may be *Namach Chel*, the distinguished Chel; or *Vamac Chel*, some one of the Chels, or, he who is a Chel.

Copo, p. 148, is the *Ficus rubiginosa* (Aznar, *Plantas de Yucatan*, p. 231).

Iztañte, p. 184, stands for *yitz tahté*, which is the native name for turpentine.

Mitnal, p. 200, is spelled by Beltran, *Arte de la Lengua Maya*, *Metnal*. Brasseur's derivation from Nahuatl *Mictlan* is probable.

Ixtab, p. 202. Compounded of the feminine prefix *ix*, and *tab*, which as a verb means "to tie to something," and as a noun, the gallows.

Uinal-Hun-Ekeh, p. 204. In the original this reads *Vinal, Hunekeh*. Of these words *uinal* is the ordinary Maya word for month; *hun* is "one"; but *ekeh* does not appear in any of the dictionaries. Perez *Dicc. Maya*, gives *Keh* as "the seventh day."

Zacab, p. 212. Brasseur explains this in a note as "une sorte de mais moulu"; but the *Diccionario de Motul*, gives *gakab*, "la caña del mais," cornstalk. The name of the deity, therefore, was "The Nine Cornstalks." On the same page, *zacah* is in the usual form *gaca*, and is pulverized roasted maize mixed with cold water. *Kanté*, on the same page, is not the cedar, as the editor supposes, which in Maya is *Kuche*, but "a tree from whose roots the natives obtain a yellow dye" (*Dicc. Motul*).

Kauil, p. 216, does not appear in the dictionaries. The Abbé's suggestion that it is an error for *Kabul* is possibly correct; or it may be for *Kaual*, which means one who is very choice in food and raiment (*Dicc. Motul*).

Batel-okot, p. 218, means "battle dance." The similarity of the Maya *batel* or *bateel*, to battle, a battle, to the English I have elsewhere noted as an odd coincidence.

Chacan-cantun, pp. 220, 222. The original has *chacacantun*, and also *Canzienal* in place of *Canziemal* in Brasseur's text.

On p. 222 and elsewhere instead of *zac-u-uayeyab*, the original text gives uniformly *zacuuayayab*.

The Translation.

Bishop Landa's writings on this subject were evidently mere memoranda, jotted down to await future arrangement and revision. The copyist contributed to their obscurity, so that passages of his *Relacion* present peculiar difficulties, some of which have led his translator wide of the mark. I shall point out some of the most notable of these.

p. 4. "tiene mucha lama"; "la plage y est tres etendue"; more correctly "a beaucoup de limon."

p. 16. "que por esto le llamaron Lazaro"; "que les Espagnols appellent de Lazare"; better "et pour cela ils l'appellent *Lazaro*."

p. 24. "seis soles" is translated "trois soleils."

p. 32. "tres cuentas de piedra buenas"; "trois objets de pierre bleu travaillés." It is not easy to see where this sense was obtained.

p. 74. The space left blank at the beginning of § xiii is unnecessary, and there is no need to supply a supposed omission. The sense is "The adelantado did not occupy the best position for one who had enemies," etc.

p. 116, line 1. The words "les parecia muy mal," do not mean "bien qu'elle leur parût mauvaise," but "ce qui les defigurait beaucoup." Later, on the same page, "cuero de venado por curtir seco," does not mean "cuir de bêtes fauves tanné á sec," but "de cuir sec de chevreuil."

p. 136. "Llamanse aora los nombres de Pilar los proprios"; "Leurs noms propres aujourd'hui sont comme Pilar," etc. This is a singular mistranslation. The baptismal font in Spanish is *pila*, and "nombres de pila" means "christened names." The meaning evidently is "they now call themselves by their baptismal names."

p. 158. Speaking of the wooden idols which descended from father to son, Landa says they were considered the most valuable part of the heritage, "tenidos por lo principal de la herencia." This Brasseur translates "ils y avaient la plus grand confiance."

On p. 174 there are two important errors. Line 2, "los quales llaman *holcanes*" does not mean "à l'appel des *holcans*," but "qu'on appellait *holcans*"; and "que á essos holcanes sino era en tiempo de guerra no davan soldada," means that the holcans did not receive pay except in time of war, and not at all "Quant aux holcans, ils n'amenaient point la milice hors du temps de la guerre."

Equally incorrect is the translation of the description of the manner in which the natives wore their mantle, p. 186. But it will not be profitable to continue pointing out such slips. I have said sufficient to show that Brasseur's translation must be carefully compared with the Spanish text before it is accepted.

A very curious error in translation occurs on pp. 48 and 172, but this time it must be charged to the account, not of the Abbé, but of the Bishop himself. On p. 48, bottom, there is the extraordinary statement that as an article of defensive armor

the natives wore "jacos fuertes de sal y de algodon," "strong jackets (made) of *salt* and cotton!" And this is repeated, p. 172, with the specific addition that these jackets were "quilted doubly with *salt for grinding!*" No wonder the Abbé was nonplussed by this outrageous assertion! (See his note to p. 49.) The explanation is interesting. The word in the Maya language for salt is *taab*, while that for a twisted strand or cord is *tab*, the only difference being in the length of the vowel. Evidently Bishop Landa, or the person from whom he derived his information, mistook the native description of these quilted jackets. They were of cotton and *twisted cords* (*tab*), the layers of the former being quilted to the latter. The historian of Yucatan, Father Cogolludo, refers to them, stating that they were called by the Mexicans (Nahuas), *ichcavipiles*. This is a sound Nahuatl word, found in Molina's *Vocabulario*, and shows that the same defense was known and employed by the Aztecs. It was also familiar to the tribes of Maya lineage in Guatemala.

The Maya Characters.

A close comparison of the various Maya characters printed in Brasseur's edition with those in the Madrid copy proves that in the main his tracings were accurate.

The Calendar beginning on p. 240 reveals, however, a number of minor differences. All of Brasseur's characters tend more to the circular form than those in the later edition which are approximately quadrangular. Occasionally points of detail differ considerably, as for instance, on p. 240, the signs *Ix* and *Cib*. The lines for the month signs are much fainter and sharper in Brasseur, and that of the month *Minan* is incomplete, lacking a bracket-shaped appendage to the left.

The Katun-wheel on p. 312 in the Madrid edition has the inscription in its centre. The Maya words should read *u uazaklom Katun*, "their return the Katuns," *i. e.*, the return or revolution of the Katuns. Brasseur translates the Spanish rendering of this, "gerra de los Katunes" by "la guerre on le jeu des Katuns." The word *gerra* means neither game nor war, but is dialectic for *gira* or *giro*, from *girar*, to turn around.

In the important matter of the alphabet on p. 320, Brasseur makes only one serious error, that is, that he places the first form of the letter b (No. 4 of his list) lengthwise instead of up-

right. He was led into what I think was another error by the disposition of the letters in the MS. As the Madrid edition gives a photo-lithograph of the two pages of the original text containing the alphabet and its explanation, we are in a position to examine it satisfactorily. The figures are arranged in three parallel lines across the page, and the two figures for *u*, stand, the first at the end of one line, the second at the beginning of the next. From their evident connection with the sign for the sky at night, I am of opinion that they belong together as members of the same sign. Or did either member of the pictographic composite serve as indicating its phonetic value?

The designs of buildings as given by Brasseur, pp. 328, 332, 342, are much neater and more regular than in the original, where they are simply out-lined with a pen neither steady nor skillful. The disposition of the parts is, however, the same in both.

From these remarks it will be seen that Don Juan de Dios de la Rada y Delgado has laid students of Maya culture under positive obligations by this new and complete edition of Landa's most important work, and it should find a place in those public and private libraries which aim to have at all a complete list of consulting Americana.

THE FACIAL NERVE IN THE DOMESTIC CAT.

BY T. B. STOWELL, PH.D.

(*Read before the American Philosophical Society, November 5, 1886.*)

Introduction.

The embarrassment of the student of comparative anatomy will be greatly relieved, and his progress will be proportionately facilitated, if he has access to a complete description of the structural characters of a typical form. The anatomy of the cat furnishes a desirable and practical standard for comparison—at least for the Mammalia. Special reasons for accepting and adopting this standard have been presented elsewhere. (Anatomical Technology, **34**, p. 55.)

The osteology and the myology have already been described (**34**, **B.C.**). The neurology has been given only in part; the anatomy of the brain has been published by Wilder in the Anatomical Technology (**34**), and in numerous papers by the same author before scientific bodies. (For the bibliography see Anatomical Technology.)

It has seemed desirable that the nerves of the cat be described with the same fullness of detail that has been given to the bones and the muscles.*

The Vagus (**27**) and the Trigeminus (**A.**) nerves have been described; the present study of the Facial nerve is now offered as a contribution to comparative neurology. It has been the author's aim to present the relations and the distribution of this nerve, based upon repeated dissections, so as to insure, as far as practicable, the elimination of individual variation.

Preparation.

The cats were injected with the "starch injection mass" recommended in the Anatomical Technology (**34**, p. 140); both arteries and veins were injected, to facilitate identification and to insure accuracy. Alcoholic and recent specimens were used. Most of the work has been done under a magnifying power of 15–25 diameters, with the hope that no anastomotic or terminal filaments should escape notice.

NERVUS FACIALIS.

Synonymy.—Portio dura (of the seventh pair), Par septimum seu faciale, Communicans faciei nervus, Sympatheticus minor, Ramus durior septimæ conjugationis, Respiratory nerve of the face, Nervus facialis, Facial nerve.

Anatomical Characters.—This nerve is distributed to the muscles which give expression to the face, viz., the muscles of the palpebral, the nasal, the maxillary, the mandibular and the inter-maxillary regions; to two of the principal muscles of the ectal ear, viz., attrahens aurem and retrahens aurem, and to the small muscles of the cartilage (pinna); it gives filaments to the middle ear, directly to the stapedius muscle, indirectly to the tensor tympani and those structures innerved by the tympanic plexus (Jacobson's nerve); it supplies the scalp (occipito-frontal muscle) and the ectal muscle of the cheek and neck (platysma myoides); it communicates with the several divisions of the trigeminus nerve upon the face, and with ganglia of the trunk, viz., with the Gasserian ganglion by a small fascicle, with the spheno-palatine through the great petrosal root of the Vidian

* For the study of individual structure the elaborate and expensive work of Straus-Durckheim (**B.**), and the more accessible reduced copies of his outline plates by Professor Henry S. Williams (**C.**), possess excellent features. The Anatomical Technology by Wilder and Gage (**34**) is all that can be desired in a manual which is designed "to furnish those who intend to pursue human, veterinary or comparative anatomy, with explicit directions for dissection and for the preparation and preservation of anatomical specimens, and with a correct and clear account of the principal parts of an accessible and fairly representative mammal of convenient size" (Preface, 2d ed.). Directions for dissection and manipulation are so explicit in this manual that it seems unnecessary to describe the methods followed in the preparation of this paper. No work known to the writer, except perhaps Mivart's (**18**), assumes to present in detail the nervous system of the cat; the wide discrepancy between his text and the nervous system of American cats has been mentioned elsewhere (**A**; The Nation, June 2, 1881; Science and the Athenæum, June 4, 1881).

PROC. AMER. PHILOS. SOC. XXIV. 125. B. PRINTED FEB. 2, 1887.

nerve, with the otic through the small petrosal, and with the submaxillary through the chorda tympani; it is joined by a considerable fascicle from the auditory nerve near the ectal origin (this is the origin of the chorda tympani, according to Sapolini), by a branch from the glosso-pharyngeal and the vagus nerves; it anastomoses with the superficial cervical and the minor occipital nerves. It is not given to the temporal muscles, although its terminal filaments form dense plexuses upon their ectal surfaces.

Physiological Characters.—This nerve controls facial expression, the movements of the ectal ear and the auditory ossicles; it has a direct action upon the salivary glands. (Sapolini ascribes speech to the chorda tympani, and thinks that the further action of the facial nerve upon the tongue is to govern its movements in deglutition). I do not know that its action upon the auditory nerve has been demonstrated. Its anatomical relations suggest a modifying influence upon the trigeminus, the glosso-pharyngeal and the vagus nerves.

SPECIAL DESCRIPTION.

Proximate Roots.—The union of the proximate roots of the facial nerve may be traced along the ventrimesal border of the sensory root of the trigeminus nerve caudad of the pons.

The dorsal root bends around the caudal root of the trigeminus, crosses its lateral and dorsal faces, and enters the cerebellum with the medipeduncle.

The cephalic root is ventrad of the caudal root of the trigeminus and caudad of the medipeduncle; a portion is reflected dorsad to the cerebellum with the prepeduncle; the larger portion dips into the floor of the epicœle, and may be traced cephalad to the region of the post optici.

The caudal root separates from the cephalic as it passes ventrad of the root of the trigeminus; it lies ventrad of the caudal root of the trigeminus, and passes obliquely meso-caudad to the floor of the metacœle.

Ectal Origin and Entocranial Relations.—The facial nerve takes its ectal origin from the latero-cephalic border of the trapezium, meso-cephalad of the auditory nerve (**27**, Figs. 1, 2; **34**, Fig. 116, and Pl. II, Fig. 3). The distribution of the cerebellar artery is such that the ectal origin is surrounded by arterioles; a small twig from the medicerebellar artery (**D**.) and a venule pass between this nerve and the auditory.

The ento-cranial course is laterad with the auditory nerve; it traverses the ental meatus auditorius with that nerve, its position being dorsad.

Just ectad of the arteriole which separates the facial and the auditory nerves a small ramus apparently unites these nerve trunks, or rather is an accession to the facial nerve. Is this the intermediary nerve of Wrisberg (*portio inter duram et mollem*)? Sapolini maintains that in man this is the origin of the chorda tympani, which he names the thirteenth cranial nerve. He traced this nerve to the geniculate ganglion, and found that the nerve of Wrisberg and the chorda tympani were one and the same nerve. (From a résumé of Sapolini's monograph by Dr. Burnett, pub-

lished in the Medical Times, February 24, 1883, and reprinted in the Medical Record, March 31, 1883, p. 362.)

Intercranial Relations.—The facial nerve traverses the serpentine flexions of the aqueductus Fallopii to the foramen stylo-mastoideum. The course in the aqueduct is first laterad for 2–3 mm.; an abrupt change in direction at this point forms an angle which is directly mesad of the fossa occupied by the spherical tensor tympani muscle; peripherad of the angle the course arches first dorsad (the concavity being ventro-laterad), then laterad (the concavity being ventrad) for 5–7 mm., and lies caudad of the tensor tympani muscle.

About 10 mm. peripherad of the ental meatus auditorius there is a considerable expansion in the aqueduct, about 3 mm. in length; in this fossa a reddish swelling rests upon the facial nerve. This is the ganglion geniculatum, or intumescentia gangliformis.*

From this point the course is laterad to the stylo-mastoid foramen.

At the angle (Fig. Ang.) a considerable twig 2 mm. in length is given off, which traverses a foramen to the ental surface of the cranium, where it divides into four ramuli, which become respectively the mesal root of the great superficial petrosal nerve, the small superficial petrosal, a ramulus to the sympathic plexus in the carotid rete arteriale, and a fascicle to the eminence on the caudo-lateral angle of the Gasserian ganglia. At a point caudad of the stapedius muscle a fascicle, the tympanic nerve, is sent to that muscle. (It is not clear but that this fascicle has its origin in the geniculate ganglion instead of the nerve trunk.)

Caudad of the geniculate ganglion the fallopian aqueduct arches latero-caudad (the concavity being mesad). In this canal, immediately caudad of the ganglion, are two fasciculi separated by a slender arteriole. These are the chorda tympani and the united anastomotic branch to the glosso-pharyngeal and the vagus nerves with the long root of the petrosal nerve, q. v. The geniculate ganglion embraces these united nerves and the trunk of the facial.

About 5–8 mm. peripherad of the ganglion, where the arch reaches its ventral angle and begins to curve cephalad (the concavity being dorsad), the anastomotic branch bends ventri-mesad, and 5 mm. peripherad it bifurcates to join the petrosal ganglion of the glosso pharyngeal nerve and the jugular ganglion of the vagus. This is a portion of the auricular branch of the vagus. This point of separation is also the origin of the long root of the great petrosal, q. v.

Chorda Tympani.—This nerve, or the nervus tympano-lingualis, has its origin and course as given above; it continues cephalad in the canal, accompanied by a slender arteriole; it bends dorsad to enter the tympanum through the *iter chordæ posterius;* it crosses the tympanum about

*The author has not at this date completed experiments to satisfy himself as to the relation of this body; whether the relation is one of position only or one of structure—that is, whether it is a ganglion of the facial nerve, or is peculiar to the great superficial petrosal nerve and merely rests upon the facial.

the middle of the malleus, somewhat mesad of the bone, and emerges through a minute foramen, the iter chordæ anterius, into the glaserian canal, thence along the canal to the ecto-cranial foramen ; it lies ventrad of the otic ganglion and the dental branch of the mandibular nerve, ectad of the external carotid artery, passes between the pterygoid muscles, and joins the lingual nerve at an acute angle about 5–10 mm. peripherad of the foramen ovale.

Nervus petrosus superficialis major.—The great petrosal nerve has a fourfold origin. The principal root may be traced to the geniculate ganglion with the trunk which is directed caudad from that body ;* the next in size comes direct from the petrosal ganglion of the glosso-pharyngeal nerve, and is a division of Jacobson's nerve ; the third is a branch from the trunk of the facial, at the angle ; and the fourth is a slender filament from the tympanic plexus (Jacobson's). The united trunk lies in the glaserian canal, and emerges from its ventral hiatus, enters the caudal foramen of the Vidian canal, which is about 5 mm. cephalad, traverses the canal, and at the middle of the foramen lacerum anterius becomes the petrosal root of the Vidian nerve, whence it is related to the spheno-palatine ganglion.

Nervus petrosus superficialis minor.—This branch from the interosseous portion of the facial nerve is one of the four divisions of the ramulus given off at the angle ; about 2 mm. peripherad of its origin it enters an enlargement (plexus?) about .5 mm. in diameter ; this enlargement is joined by the tensor tympani nerve ; the petrosal nerve traverses the glaserian canal and joins the otic ganglion at the ventral hiatus.

Ecto-cranial Relations.—The ecto-cranial trunk emerges from the foramen stylo-mastoideum ; its course is cephalad and dorsad, and lies ectad of the post-auricular artery. (It often lies entad of a branch artery to the parotid gland.) At the foramen of exit, or just peripherad, the nerve divides into branches ; its relations and distribution are given accordingly. The primary rami ventrad are the digastric and the stylo-hyoid ; cephalad are the cervico-facial and the temporo-facial ; dorsad and caudad are the auricular.

N. digastricus.—The digastric nerve is a small ramus from the ventral border of the facial nerve at its foramen of exit ; it lies entad of the stylo-mastoid artery, around the cephalic border of which it bends abruptly and takes its course ventrad ; it extends along the dorsal border of the proximal end of the digastric muscle, which it penetrates about 5–8 mm. from its origin ; its terminal filaments supply the proximal end of the muscle. (I do not find an anastomotic branch to the glosso-pharyngeal nerves, as is the case in man.)

N. stylo-hyoideus arises from the ventral border of the facial nerve, in common with the digastric, or remains in the trunk-sheath to be given off about 1–2 mm. peripherad ; it penetrates the stylo-hyoid muscle at its

* This trunk becomes the anastomotic branch to the glosso-pharyngeal and the vagus nerves, the chorda tympani and the long root of the petrosal nerve.

proximal third, and is distributed throughout the muscle; it often communicates with the cervico-facial nerve about 10 mm. peripherad of its origin. As it crosses the post-auricular artery it gives two or three filaments to the sympathic plexus around this blood-vessel.

Cephalic Division of the Nerve-Trunk.—As the common trunk emerges cephalad from the foramen of exit, it lies dorsad of the stylo-mastoid artery (a small twig from the post-auricular), and crosses the lateral border of the post-auricular artery; at the dorsal border of the artery the trunk divides into the cervico-facial and the temporo-facial rami. (In some instances this trunk seems to give origin to the stylo-hyoid nerve.)

N. cervico-facialis.—This is the cephalic and ventral ramus of the common trunk; it is ectad of the carotid artery and the facial vein, entad of the submaxillary gland, and upon the ectal surface of the masseter muscle. At the cephalic border of the submaxillary gland it divides into three rami, the infra-maxillary, supra-maxillary and the buccal.

The first branch of the cervico-facial trunk is given off at the origin of this nerve; it lies ectad of the carotid artery, and is directed dorsad and laterad upon the ectal surface of the parotid gland; about 12 mm. from its origin, ectad of Stenon's duct, it bifurcates, each division again branching into two or four ramuli and terminating in the dermal muscle ectad of the gland (Platysma myoides). A few filaments may be traced to the zygomatic muscles.

This branch receives a considerable accession from the temporo-facial nerve near its origin; some of the filaments seem to terminate in the substance of the parotid gland.

5–8 mm. peripherad of the origin of the cervico-facial nerve a second fascicle is sent to the zygomatic muscles.

N. infra-maxillaris.—This is the ventral division of the cervico-facial nerve; it lies ectad of the facial artery and the facial vein; 5 mm. peripherad of its origin it divides into several ramuli which anastomose freely and terminate upon the platysma. A large fascicle joins the superficial cervical nerve from the cervical plexus.

N. supra-maxillaris.—This is the middle division of the cervico-facial nerve. (It often arises as a branch of the buccal nerve, given off at the border of the orbicular muscle at the angle of the mouth; its distribution is constant.)

Its general course is toward the angle of the mouth; it lies ectad of the facial artery and vein; it forms a dense plexus upon the ectal surface of the ventral lip; the ventral ramuli supply the muscle between the foramen mentale and the mandibular symphysis (M. depressor labii), and anastomose with the mental branch of the mandibular division of the trigeminus nerve; its filaments are also given to the orbicular muscle (M. orbicularis oris).

N. buccalis is the dorsal branch of the cervico-facial nerve; it gives several anastomotic filaments to the infra-orbital branch of the temporo-facial nerve; it joins the plexus at the angle of the mouth (Plexus labi-

alis); a ramuscle is inflected around the angle of the mouth and anastomoses with the buccal branch of the mandibular division of the trigeminus; it reaches the following muscles: the buccinator, the orbicular, the zygomatic, the risorius and the depressor anguli oris; it continues mesad along the dorsal lip between the superior coronary artery and the vein just dorsad, and at the lateral border of the arteriale rete, just dorsad of the canine tooth, the infra-orbital and the buccal nerves anastomose and form a plexiform swelling for 3–5 mm.; from this united nerve fibres diverge to the levator muscles and to the muscles upon the nasal cartilage.

N. temporo-facialis.—This is the dorsal division of the cephalic trunk as it crosses the post-auricular artery; it is considerably larger than the cervical division (N. cervico-facialis); it lies ectad of the external carotid artery, entad of the ventral lobe of the parotid gland and the adjacent lymphatic gland, and upon the ectal surface of the masseter muscle. Entad of the parotid gland, and 10 mm. peripherad of origin, it divides into three rami—the ventral, or infra-orbital; the middle, or malar; and the dorsal, or temporal (the malar and the temporal often remain in a common sheath for 10–12 mm., forming the temporo-malar trunk).

N. infra-orbitalis.—This, the ventral division of the temporo-facial nerve, emerges from the cephalic border of the parotid gland just dorsad of Stenon's duct; its course is arched toward the angle of the mouth, about midway between Stenon's duct and the zygoma, and lies upon the ectal surface of the masseter muscle; it sustains anastomotic relations with the malar nerve and the temporo-auricular division of the trigeminus nerve. At the ventral border of the zygomatic muscle it gives anastomotic filaments to the cervico-facial nerve, as described; it lies ectad of the zygomatic muscles and dorsad of the superior coronary artery. At the angle of the mouth it gives filaments to the dorsal part of the orbicular muscle; in its course along the dorsal lip it supplies the levator muscles, the muscle at the base of the vibrissæ and the muscles which move the nasal cartilage; it joins the buccal nerve to form the plexiform enlargement in the rete arteriale dorsad of the canine tooth, as already described (v. N. buccalis).

N. malaris.—This is the middle and large division of the temporo-facial nerve; the central portion is covered by the parotid gland; entad of the gland it communicates freely with the temporo-auricular nerve. At the dorsal border of the gland it is apposed to the cephalic temporal artery, and continues along with the artery just caudad of the supra-orbital ridge (the tension of the muscle will dispose the nerve cephalad or caudad of the artery). The principal divisions of the nerve make a dense plexus upon the ectal surface caudad of the supra-orbital ridge; the terminal filaments are given to the occipito-frontal muscle over the frontal region where they anastomose with filaments of the supra-orbital nerve. At the lateral angle of the eye, where a fascicle joins the supra-orbital, a slender nerve is given off to the zygomatic muscles. The nerve trunk may be

traced along the supra-orbital ridge to the mesal angle of the eye, where it joins the infra-trochlear nerve.

N. temporalis.—The temporal branch of the temporo-facial nerve lies close to the basal cartilage of the ectal ear and entad of the parotid gland. The central portion communicates with the temporo-auricular nerve and sends filaments to the attrahens muscle.

At the dorsal border of the gland, and at the ventral border of the long triangular cartilage which is directed meso-cephalad from the dorsal angle of the ectal ear, and which is embedded in the occipito-frontal muscle, the nerve divides; one portion, passing ectad of the cartilage, is distributed to the occipito-frontal muscle in the parietal region; the other, passing entad of the cartilage and along its ventral border, joins the supra-orbital plexus already described.

N. post-auricularis.—This nerve emerges from the stylo-mastoid foramen, and takes its course dorso-caudad in a groove upon the ectal surface of the mastoid process. The central 5 mm. form a loop around the post-auricular artery, one division lying ectad and the other entad of the vessel. These may be described as the auricular and the occipital portions.

The auricular portion, at the peripheral end of the loop, lies apposed to the ectal or caudal division of the artery,* and is distributed to the lateral border of the occipito-frontal muscle. A ramulus from this nerve is given to the retrahens muscle.

The occipital portion lies between the two branches of the post-auricular artery and is distributed to the caudal part of the occipito-frontal muscle; it communicates with a branch of the minor occipital nerve (N. occipitalis minor).

Ramuli to the Ectal Ear.—A ramulus from the auricular nerve is directed toward the tip of the ear; 10 mm. from its origin it gives off 4–5 ramuli, which supply the dermal muscle of the latter half of the ectal ear (probably the platysma); the nerve follows an arteriole around the caudal and the dorsal borders of the ectal ear, and bending around the cephalic margin just distad of the attrahens muscle, it supplies a muscle (helicis major?) upon the ental surface of the ear.

From the ental surface of the facial nerve at the stylo-mastoid foramen a considerable fascicle is directed dorsad close to the proximal cartilage of the ectal ear and entad of the auricular muscles; it penetrates the cartilage and terminates in a muscle (helicis minor?) upon its ental surface mesad of a projection from the ental surface of the ear near the external meatus.

A third ramulus takes its orgin at the stylo-mastoid foramen; it is ectad of the post-auricular artery, and crosses the base of the second arteriole, which is sent dorsad from the post-auricular; it follows a small arterial twig about 6–8 mm., when it perforates the auricular cartilage with the

* The artery divides just peripherad of the loop.

arteriole, and terminates upon the thin muscle (anti-tragicus?) at the base of the ear centrad of the folds which extend from the external meatus to the marginal "pocket" of the ectal ear.

SUMMARY.

Anatomical.

PROXIMATE ROOTS.—The dorsal root proceeds from the cerebellum with the medipeduncle.

The cephalic root has one ental origin in the region of the floor of the epicœle or the post-optici part of the mesocœle, and another in the cerebellum, whence it proceeds with the prepeduncle.

The caudal root originates in the caudal portion of the floor of the metacœle.

ECTAL ORIGIN.—This is from the latero-cephalic border of the trapezium; it is separated by an arteriole and a venule from the auditory nerve.

THE EXIT is by the meatus auditorius entalis, dorsad of the auditory nerve, through the aqueductus fallopii, and emerges from the foramen stylo-mastoideum.

PRINCIPAL ECTOCRANIAL DIVISIONS AND THEIR DISTRIBUTION.—Nervus digastricus is distributed to the musculus digastricus; N. stylo-hyoideus to M. stylo-hyoideus; N. cervico-facialis to the MM. platysma, orbicularis oris ventralis, depressor labii ventralis, depressor anguli oris, risorius; N. temporo-facialis to the MM. orbicularis oris dorsalis, buccinator, zygomatici, levatores labii dorsalis, orbicularis palpebræ, occipito-frontalis, attrahens aurem; N. auricularis to the MM. occipito-frontalis, retrahens aurem, helicis major, helicis minor, antitragicus.

COMMUNICATING RAMI.

Ento-cranial.—The facial nerve receives an accession just peripherad ot the arteriole which separates it from the auditory; this is probably the intermediary nerve of Wrisbery, or the root of the chorda-tympani (Sapolini's thirteenth cranial nerve).

Inter-cranial.—The facial nerve communicates with the spheno-palatine ganglion by the great superficial petrosal root of the vidian nerve; with the otic ganglion by the small superficial petrosal nerve; with the sympathetic plexus by the lateral petrosal nerve; with the Gasserian ganglion of the trigeminus by an anastomotic filament from the ramus at the angle in the aqueduct; with the petrosal ganglion of the glosso-pharyngeal by a large fascicle from the geniculate ganglion; with the jugular ganglion of the vagus by the same fascicle; with the lingual branch of the trigeminus by the chorda tympani; with the stapedius muscle by the tympanic nerve; with the tensor tympani by filaments from the small superficial petrosal nerve.

Ecto-cranial.—The facial nerve communicates with the superficial cervical nerve by the infra-maxillary branch; with the mental nerve (mandibular division of the trigeminus) by the infra-maxillary; with the

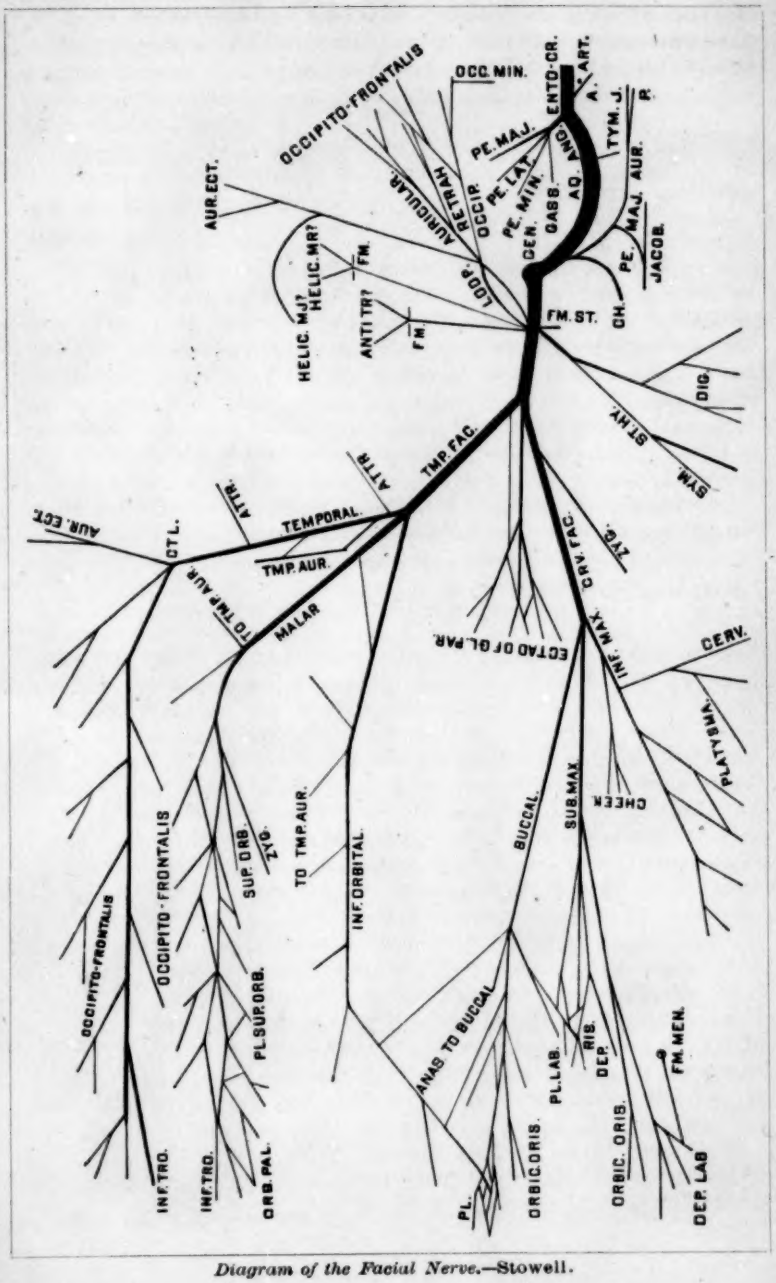

Diagram of the Facial Nerve.—Stowell.

buccal nerve (trigeminus) by the buccal branch; with the auriculo-temporal (trigeminus) by the infra-orbital branch; with the supra-orbital nerve (trigeminus) by the malar branch; with the supra-orbital and auriculo-temporal by the temporal branch; with the great auricular nerve (spinal) by the auricular branch; with the small occipital nerve (spinal) by the occipital branch.

There seems to be no anatomical relation between the facial nerve and the masseter muscle, although the nerve ramuli make a complex network over the ectal surface of the muscle.

Physiological.

The facial is the motor nerve of the face; it excites contractility in the muscles of the middle ear, the ectal ear (except M. attolens aurem), the cheeks, the scalp, the lips, the nostrils, the eyelids and the neck (platysma). Through the vidian nerve it modifies the movements of the muscles which are controlled by nerves whose immediate origin is the spheno-palatine ganglion. Its action upon the salivary glands through the chorda-tympani is generally accepted; further investigation may confirm Sapolini's theory that the chorda-tympani controls speech. Its anastomotic relations with the branches of the trigeminus suggest that much of the motor function in structures supplied by that nerve may be referred to the facial. It is intimately related with the glosso-pharyngeal and the vagus nerves. Its relation to audition is unknown.

DESCRIPTION OF THE DIAGRAM.

The diagram is not drawn to a scale. No attempt has been made to represent the nerves in perspective. To secure simplicity, it has been necessary to change the relative proportions and directions of nerves which intersect or lie in planes at considerable inclination.

A., the accession from the auditory nerve, the intermediary nerve of Wrisberg and root of the chorda-tympani (Sapolini); *Ang.*, the angle in the interosseous trunk; *Antitr.?*, the thin muscle upon the ental surface of the ectal ear, which has been provisionally identified as the antitragicus; *Aq.*, the intercranial trunk in the aqueductus fallopii; *Art.*, the twig from the anterior cerebellar artery which separates the facial and the auditory nerves at their ectal origins; *Attr.*, the filaments to the M. attrahens aurem; *Aur.*, the anastomotic branch of the petrosal ganglion of the glosso-pharyngeal nerve and to the jugular ganglion of the vagus; *Auricular*, the auricular division of the post-auricular nerve; *Aur. Ect.*, the ectal ear; *Cerv.*, the anastomotic filament to the superficial cervical nerve; *Ch.*, the chorda tympani; *Cheek*, filaments to the muscle ectad of the parotid gland; *Crv. fac.*, the cervico-facial division of the facial nerve; *Ctl.*, the position of the long triangular cartilage at the base of the ectal ear; *Dep.*, filaments to the M. depressor anguli oris; *Dep. lab.*, to the M. depressor labii ventralis; *Dig.*, the digastric nerve; *Ento-cr.*, the ento-cranial trunk; *Fm.*, the position of the small foramina in the carti-

lage of the ectal ear through which the nerves pass to the ental muscles; *Fm. men.*, foramen mentale; *Fm. st.*, foramen stylo-mastoideum, the foramen of exit of the facial nerve; *Gass*, the anastomotic filament to the caudo-lateral eminence upon the Gasserian ganglion; *Gen.*, the geniculate ganglion; *Gl. par.*, the parotid gland; *Helic. mj.*, the helicis major muscle (provisional); *Helic. mr.*, the helicis minor muscle (provisional); *Inf. max.*, the infra-maxillary nerve; *Inf. tro.*, the infra-trochlear branch of the trigeminus; *J.*, ramus to the jugular ganglion; *Jacob.*, Jacobson's nerve; *Occip.*, the occipital branch of the post-auricular nerve; *Occipito-frontalis*, filaments to the occipito-frontal muscle; *Occ. min.*, to the small occipital nerve; *Orbic. oris*, to the musculus orbicularis oris; *Orb. pal.*, to the orbicularis palpebrarum; *P.*, ramus to the petrosal ganglion; *Pe. lab.*, the lateral petrosal branch to the sympathic plexus; *Pe. maj.*, the short root of the great superficial petrosal; *Pe. maj.'*, the long root of the same; *Pe. min.*, small superficial petrosal; *Pl.*, the plexus in the rete arteriale dorsad of the canine tooth; *Pl. lab.*, the plexus at the angle of the mouth; *Pl. sup. orb.*, the supra-orbital plexus; *Retrah.*, to the musculus retrahens aurem; *Ris*, to the risorius muscle; *St. hy.*, the stylo-hyoid nerve; *Sup. max.*, the supra-maxillary nerve; *Sup. orb.*, the supra-orbital branch of the trigeminus nerve; *Sym.*, the filament to the sympathic plexus around the artery; *Tmp. aur.*, the auriculo-temporal branch of the mandibular division of the trigeminus; *Tmp. fac.*, the temporo-facial division of the facial nerve; *Tym.*, the tympanic branch to the stapedius muscle; *Zyg.*, filaments to the zygomatic muscles.

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James R. Ludlow. By Richard Vaux.

(*Read before the American Philosophical Society, January 7, 1887.*)

The American Philosophical Society in recording its tributes to the memory of its deceased members is sensibly impressed by the reflection that the propriety of their election to its membership had been signally confirmed by the learning and attainments manifested in their life-work.

Knowledge is advancing to the circumference which bounds the human mind. Science is laboriously engaged in finding out the reason of things. Philosophy in the library is exercising its capacities, and elsewhere testing its ability to demonstrate them. Out of these sources our Society is filled with vital force. Those who augment and increase its value are within the compass of our commendation.

The preparation of this paper is the practical exemplification of this axiom. It is dedicated to the memory of the HON. JAMES R. LUDLOW.

On the 3d of May, 1825, in the City of Albany, in the State of New York, James R. Ludlow was born. His father, the Rev. Dr. John Ludlow, was a minister of the Old Dutch Reformed Church. This venerable Society had an historical character. Its influence in the earlier days of New York was marked, and much yet remains. The Dutch settlers of that Province were earnest, sincere, sluggish, but patriotic people. The Patroons were noted men in their time. The Van Rensselaer Manor was historical. The Patroons, Van Rensselaer, even to a late period were esteemed and respected in social circles.

The anti-rent excitement half a century ago, was evolved out of the relations between these manors and the tenants.

The Rev. Dr. Ludlow was an educated, cultivated gentleman. He was professor of languages in the Theological Department of the New Brunswick, New Jersey, School of the Dutch Reformed Church.

In the year 1834 Dr. Ludlow came to Philadelphia and was elected Provost of the University of Pennsylvania, in which post he served for nearly twenty years.

When Dr. Ludlow came to this city, his son James entered the University of Pennsylvania and graduated with distinction in July, 1843.

He then became a student of law with the Hon. Wm. M. Meredith. It may not be out of place to say of Mr. Meredith that he was one of the ablest lawyers of this country. Well read in all branches of learning, with a brilliant wit, his fame was the growth of inherent ability and marvelous culture. Without industry, he absorbed knowledge. His reading was general, his memory phenomenal.

On the admission of James R. Ludlow to the bar on July 24, 1846, he entered on the practice of his profession in this city. Earnest, faithful, industrious, he began to establish a professional character that promised success.

In 1850 he was appointed Assistant District Attorney of the United

States and earned high repute for his conduct of some of the Government cases. He learned rapidly the science of the law, and mastered its practical details.

In 1856 he was named as a candidate for the District Attorneyship of Philadelphia. His reputation had grown, his professional standing was assured.

In 1857 he was nominated for Judge of the Court of Common Pleas of Philadelphia County, and elected, and in November, 1857, took his seat on the Bench. His term of ten years expired in 1867, and he was re-elected.

By the Constitution of the State of Pennsylvania, which was amended in the year 1873, the Courts of the County of Philadelphia were re-organized. By this organic law, four Courts of Common Pleas were established. Each had a President Judge and two Associates. Judge Ludlow became President Judge of Court of Common Pleas, No. 3.

In 1877 Judge Ludlow was again elected without opposition. He held that position until his death. His judicial life began in 1857, and ended, by his death, in 1886. Thirty years of judicial labor was the training he received. He gained the respect and confidence of his fellow-citizens. They appreciated his honesty, impartiality, his courage and his learning.

As a Judge, his reputation was substantial. In the law and equity sides of the Court he was admittedly a safe and conservative administrator of the high trust conferred on him. His conscientiousness was proverbial. He possessed and developed the highest courage in the impartiality with which he adjudged the questions he was called upon to determine. It may be said he died the victim of continuous, conscientious labors. He investigated and examined, and came to his conclusions after patient study of the law involved in the decisions of those cases, the importance of which made severe demands on his time. He took nothing for granted. He believed his duty required his best efforts, and was not satisfied that errors inconsiderately made might be possibly corrected in a court of review.

It may be said of Judge Ludlow, that in dealing with the science of the criminal law he became an authority in this country. His tastes led him to study physiology and psychology. To facilitate his labor he attended the lectures in the medical school of the University of Pennsylvania. He therefore became well informed in medical science. In administering the criminal law, his opinions were regarded as a settlement of those principles in which a knowledge of these sciences was necessarily involved.

It became a professional fashion to plead insanity to indictments for murder. The first tentative efforts to introduce this defence seem to have been so successful as to encourage its adoption. The Courts, leaning to the doubt as to the mental condition of the accused when put in issue on a trial, created a demand for medical evidence in support of this plea.

It became important to the administration of justice that a rigid enforcement of the law should be secured.

To relieve one guilty of murder from the just penalty of his crime, by the interposition of a scheme to confess the act and avoid the conviction, by the assertion that the accused was insane, needed to be subjected to the test of scientific investigation. Medical experts who look up the specialty of mind diseases made of it a sort of avocation.

There ought to be a significant distinction between an "expert" and a "witness." This distinction is not always made in these trials. An "expert" is almost always called as a witness, while his function as an "expert" is to give merely professional opinions. Many of these experts, so called, were too ignorant to do more than cast suspicion on the value of any medical testimony. It was not long before the intelligent of both professions became disgusted with this expert system of building up a theory of want of mental responsibility for acts committed.

Judge Ludlow was one of the first of the Judges in Philadelphia to defeat the purpose for the use of these medical experts.

In the Commonwealth vs. Sayres, he laid down the principles which should govern the investigation of insanity as a plea against a conviction of murder. The Supreme Court of Pennsylvania confirmed Judge Ludlow's law in this case.

His opinion in this case became recognized authority. The Insane Asylum at Utica, New York, published that opinion as canon law on this subject.

The case of the Commonwealth vs. Taylor, 1884, was perhaps the most important of all the cases which were subjected to judicial determination. To those best informed as to the character of the prisoner, there was no doubt of his entire responsibility for the crime of murder of which he was convicted and afterwards hanged.

The insanity plea was fully discussed, and the Supreme Court on appeal finally settled the law on this subject in the Commonwealth, by endorsing Judge Ludlow's opinion in Taylor's case. From that opinion we make the following extract as indicating his views and asserting the law as now settled :

"I do not intend to review the law as settled by our Supreme Court in Sayres' Case, 7 Norris, 291, upon the subject of insanity.

"I tried that cause, and the charge then delivered was before the appellate tribunal. On the trial of this case I quoted from that charge freely, and added the words contained at the end of the ninth reason for a new trial of record.

"My object was to draw a line of distinction between what may be called *legal* and *medical* insanity, between acts which an eccentric, angry, jealous, sentimental and revengeful man may do, when medically and scientifically, in one sense, insane, and when by every *legal* test that man is a responsible being, and for the protection of society must be held so to be.

"It is quite possible for one to commit a violent act, when by reason of

very many causes, his brain is not in a healthy condition, is in fact diseased. He knows the circumstances by which he is surrounded, is perfectly able to attend to his own affairs, distinguishes right from wrong, and yet by reason of an unhealthy brain, is abnormally swayed by passion, sentiment and emotion, and in a fit of anger, jealousy or revenge, kills another.

"When an expert, in answer to the question

"'Suppose a case to arise, in which the diseased condition of the brain produces jealousy, anger, or revenge; is that man insane?' Answered, Yes. I then remarked: 'That is the sort of insanity the Supreme Court declares shall make a man responsible.'

"That opinion is yet entertained. If the expert had answered, 'Yes, it satisfied that this diseased or unsound state of mind existed to such a degree, that although he (the prisoner) could distinguish between right and wrong, yet, with reference to the act in question, his reason, conscience and judgment were so perverted as to render the commission of the act in question a duty of overwhelming necessity,' we could then understand the difference between an opinion based upon scientific metaphysics, under cover of which every wicked man may be declared to be insane, and a clear cut, well defined rule of law, which requires every man to be a responsible agent, and adopts rules to test that responsibility, which every one can understand and apply, and which will in practice rarely, if ever, consign to the gallows a really insane man.

"It is hardly probable in this enlightened age that one whose insanity is difficult of detection, and whose case may therefore be real, as well as mysterious, will ever be unjustly punished. When courts and juries deal with cases of insanity, they can and should only be governed by plain principles, readily applicable to facts as proved, and not indulge in impracticable theories, often subtle, and to the ordinary mind incomprehensible, which lead to the acquittal of the guilty, and to the final destruction of that security which society demands."

It is fortunate for medical and legal science, that a check was imposed on the vagaries of experts on mental disease.

The closest and best informed student of mental phenomena must know that it is impossible to establish and formulate any certain rules to make a reliable diagnosis as to special mental maladies. Abnormal mental conditions develop themselves to the recognition of educated and experienced observation. Inherited traits, latent physical causes, morbid moral alienations may express themselves in forms which indicate the existence of some irrational mental conditions. In such cases the theorist accepts a conclusion of insanity. But under which of the terms used to describe this disease it can be classified, is only to be known by the results of practical personal observation of those familiar from long experience with the various characteristics of these maladies. A theoretic opinion is of little value. Mental disturbance may exist, and become apparent under certain forms, to the expert, when if by long and close ob-

servation of those familiar with mental disease the responsibility of the individual for acts cannot be doubted. When, therefore, it becomes a question of the responsibility of a person for his acts, a theory is too often misleading.

Judge Ludlow, in his opinion in Taylor's case, has drawn the distinction with the force of scientific truth when he says, Scientific metaphysics, as applied to mind disease, may suggest medical insanity. Whatever medical insanity may be, it is now clearly determined to be the law in Pennsylvania that insanity to be a defence in murder must be determined by legal principles. Responsibility for crime is now to be determined by legal tests. Medical insanity resting on scientific metaphysics may be accepted as authority by medical experts, but before the law, legal insanity can only be recognized.

This enlightened and learned Judge, worn out by judicial labor, ended his days on the 20th day of September, 1886, in the 62d year of his age, with a high reputation, gained and earned in the thirty years of devotion to the conscientious discharge of his high trust.

It is due to the character of James R. Ludlow, that the American Philosophical Society should enroll his name among those of its members who worthily obtained and richly merited by his life-work the honorable distinction of its membership.

CONTRIBUTIONS FROM THE CHEMICAL LABORATORY OF THE UNIVERSITY OF PENNSYLVANIA.

No. XXIX.

CONTRIBUTIONS TO MINERALOGY.

BY F. A. GENTH.

(With one phototype plate and three wood-cuts.)

(*Read before the American Philosophical Society, March 18th, 1887.*)

I. ON THE OCCURRENCE OF TIN ORES IN MEXICO.

The ores which are the subject of the following investigation were received in January, 1885, from Mr. John L. Kleinschmidt of San Miguel del Mesquital in the State of Zacatecas, Mexico,* to whom I am greatly indebted for this gift, and for highly interesting observations, regarding

* I have just learned from Mr. Kleinschmidt that he has returned to Hillsboro', Jefferson Co., Mo.

their occurrence. They are all from the Sierra de Catatlan, in the State of Durango, and comprise the following:

No. 1. Ore from Mina del Diablo. "Clace 1ª, Cristal."
" 2. " " " " "Clace 2ª.
" 3. " " " de San Antonio.
" 4. Washings received from Mr. W. Schlemm.
" 5. Ore from Mina Varosa.
" 6. Stream tin ore, marked "Superior de Placer."

The central body of the Sierra de Catatlan, in which the mines which have furnished these ores are situated, consists of quartz-porphyry, which, in some places, is traversed, in a net-like manner, by small veins of tin ores. About one mile from the Mina del Diablo doleritic rocks occur.

Nos. 1 and 2. The vein of the Mina del Diablo has been traced for about one mile in length, it has a thickness of from eighteen inches to two feet, is almost perpendicular, and perfectly separated from the porphyry by argillaceous selvedges. It consists of a decomposed white clayey material, containing druses of quartz with tin ores. In a pocket was found a white clay in which crystals and crystalline aggregations (No. 1), and also finer ore (No. 2), were intermixed. On washing, this pocket yielded about 54 per cent of clean ore, the crystals and crystalline aggregations were picked out from a large quantity of clay, and weighed about 650 grms, yielding nearly 50 grms in well defined shape.

This occurrence is completely exhausted; the deeper and harder portions of the vein contain tin ores, but not any of these peculiar crystals. A qualitative examination of the crystals as well as of the finer ores, although different in form, showed the composition of mimetite, mixed with more or less cassiterite, small quantities of porphyry, quartz, hematite, clay, etc. Many interesting specimens of cassiterite, mostly of a red variety, were picked out from the mimetite crystals and crystalline aggregations; they all showed such an unusual appearance that it was desirable to obtain a larger quantity from the second-class ore. The finer portion was separated by a sieve of 16 meshes to the square inch, and 500 grms. of the siftings treated with hydrochloric acid until all the mimetite was dissolved. The residue was treated with Thoulet's solution, which gave in the heavier portion a little over 15 grams of cassiterite with a few crystals of hematite, while the lighter consisted principally of quartz, with little feldspar, fragments of porphyry, kaoline, etc.

A fuller description and analyses of the various minerals and varieties from the Mina del Diablo will be given in the sequel.

No. 3. The San Antonio Mine has furnished in a seam, six inches in thickness, a length of ten feet, and a height of eight feet, an ore in the form of pulverulent or very friable, earthy yellowish masses, with darker, somewhat more ferruginous streaks. There were only a few very small particles of the red variety of cassiterite present, most of it being of a yellowish color. A partial analysis gave:

SnO_2	=	31.27
Bi_2O_3	=	6.10
As_2O_5	=	10.13
PbO	=	8.58
Al_2O_3, Fe_2O_3	=	11.39
SiO_2	=	14.20
Sb_2O_5, ZnO, MgO, CaO, by diff.	=	12.64
Ignition	=	5.69
		100.00

A portion of the ore, after washing off the lighter particles and removing the little friable lumps, which showed but a few pseudomorphous crystals of mimetite composition, by a sieve of 16 meshes to the inch, a yellowish sandy powder was obtained, which was analyzed. It was first treated with dilute nitric acid for the determination of chlorine, and then dissolved as far as possible in hydrochloric acid.

The solution contained:

Cl	=	0.070
SiO_2	=	1.235
P_2O_5	=	0.075
As_2O_5	=	14.290
Sb_2O_5	=	0 263
SnO_2	=	3.860
Bi_2O_3	=	5.190
CuO	=	0.195
PbO	=	9.482
ZnO	=	3.940
Fe_2O_3	=	4.955
Al_2O_3	=	7.630
MgO	=	0.200
CaO	=	2.120
	=	53.505

The insoluble contained:

Quartz	=	10.640		
SnO_2	=	19.300	= 0.129	= 16
As_2O_5	=	1.844	= 0.008	= 1
Sb_2O_5	=	1.040		
PbO	=	0.198		
Fe_2O_3	=	2.945		
Al_2O_3 with traces of ZnO, Bi_2O_3, MgO, CaO	=	3.208	= 39.175	
Ignition	=	7.320	= 7.320	
			100.00	

The ores from both mines are melted together with other tin ores, and yield a crude metal, which, after some purification, furnishes a tin, very

well adapted for soldering, notwithstanding the considerable quantities of lead and arsenic which it contains.

No. 4. The washings from the Catalan mountains, which Mr. Kleinschmidt received from Mr. W. Schlemm, are highly interesting. They consist of a fine sand, the particles rarely over 1^{mm} in size.

There were no lead ores present, but cassiterite, mostly in the red variety, but also minute quantities of the yellow, interesting forms of hematite and alterations of the same, a few crystals of topaz, many minute crystals of durangite, quartz, etc.

No. 5. The ores from Mina Varosa are exclusively of the yellow variety.

No. 6. The Placer ores are both of the red and yellow varieties, the former largely predominating, also pieces showing bands of the yellow alternating with a brown variety.

For comparison several other varieties of Mexican cassiterite were examined which were kindly presented by Messrs. Clarence S. Bement, Joseph Wharton, Prof. Carlos F. de Landero, and Dr. Joseph Leidy, to all of whom I am greatly indebted for their liberality; I am also under great obligations to Professors Gerhard vom Rath and George A. Kœnig, for generous aid rendered in the preparation of this paper.

1. Cassiterite.

As already indicated, cassiterite occurs in Mexico principally in two varieties, the most abundant of which has a red color, while the other is yellow.

a. Red variety.—Occurs in various shades of red, from bright hyacinth red, brick-red to brownish red, to brown and brownish-black. The powder is from pale to brownish brick-red. The general appearance of the red cassiterite proves that the dioxide of tin was in solution from which it has been deposited upon whatever substances it came in contact with, so that numerous imitative shapes were produced. Thus, we find it as incrustations in plate-like masses which formed upon quartz or porphyry, or in reniform, mammillary, or botryoidal aggregations, frequently in perfect stalactites, which are sometimes not over 0.5^{mm} in length, often hollow, radiating from the centre, often in forms resembling sponges, roots, clubs, &c.; sometimes granular and compact, especially larger masses, which closely resemble compact hematite, towards the exterior frequently assuming a fibrous structure which may end in distinguishable crystals. The outside of the stalactites is frequently covered with exceedingly minute crystals which, however, are so small and irregular that their form can only be determined in very few cases without a microscope. Some microscopic groups of crystals obtained from the Ore No. 2 from Mina del Diablo, most of them not over 1^{mm} in size, are composed of an aggregation of apparently hexagonal plates of a bright hyacinth-red color with rounded

edges, some show flat hexagonal prisms, upon quartz or porphyry, a few also are groups of minute hematite crystals, together with those of hyacinth-red cassiterite. The most remarkable and only specimen which is large enough to distinguish its form with the naked eye came from the pseudomorphs of mimetite composition of the Mina del Diablo.

It is a little group of $7^{mm} \times 5^{mm}$ in size, composed of dark hyacinth-red crystals. There may be ten or more little crystals present, but only a few are perfect enough to show the form, but even these have somewhat curved faces and are not smooth enough and are too much interrupted to allow of an accurate measurement. They are slightly barrel-shaped, apparently hexagonal prisms with hexagonal pyramid and basal plane; the largest is 3^{mm} high and of about the same diameter.

The specific gravity of the group was found to be = 6.496, which is evidently too low, probably on account of the presence of a nucleus of quartz or porphyry around which the crystals may have formed.

The question presented itself, whether the observed forms were really hexagonal, in which case the dioxide of tin would be dimorphous, or, whether they were resulting from the twinning of tetragonal forms. In order to obtain a conclusive answer, I submitted this group, and also crystalline sands from the washings, received from Mr. Schlemm, to Prof. Gerhard vom Rath, in Bonn.

I am greatly indebted to him for his aid in this matter, which was exceedingly difficult to determine on account of the great minuteness of these crystals, so that only one of so much experience and perseverance as he has could attempt to solve this important question.

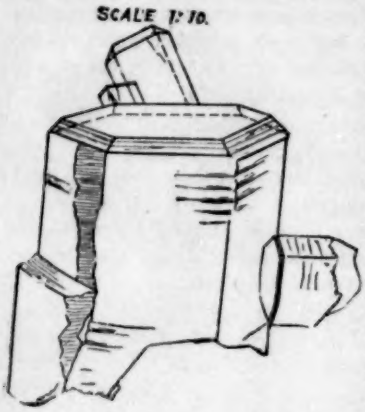
He found nearly 135° for the angle made by the *apparent* basal plane and face of the hexagonal pyramid, which closely corresponds to the angle produced by the first and second tetragonal pyramids of cassiterite. For one prismatic edge he found 112½° (must be 120° in the hexagonal system), and this angle, too, is the ordinary angle of the geniculated edge of cassiterite twins. Furthermore, he was enabled to pick out crystals from Mr. Schlemm's sands, with which approximate measurements of the angles between the basal plane and the six planes of the *apparent* hexagonal pyramid could be made, which gave: 134° 10′, 135° 15′, 135°, 134°, 135°, and 134½°, in agreement with the above measurements, as closely as could be expected.

He writes in his last note, under date of October 26th, 1886, referring to the small group of crystals: "You may consider the determination as *quadratic* beyond question, assuming an hexagonal habitus by repeated twinning."

The twin combination resembles figure 162, page 159, in J. D. Dana's "Mineralogy," 1868. I am indebted to Dr. Kœnig for the accompanying drawing, illustrating my group of crystals:

Besides the localities mentioned, I have received the red cassiterite from Coneto, in the State of Durango, Comanja and Paso de Sotos, in the

State of Jalisco. Professor G. vom Rath, in his "Geologische Briefe aus Amerika" (Sitzungsberichte der Niederrheinischen Gesellschaft für Natur und Heilkunde in Bonn, July 7th, 1884), mentions it as woodtin, implanted in red porphyry in the Valle San Francisco, San Luis Potosi, also between Sta Rosa and La Fragua, in Guanaxuato, and at Sain Alto and several other localities in the Sierra Zacatecana.



The following analyses of the red variety were made: *

1. Bright brick-red, fine granular, somewhat reniform, the surface assuming slightly fibrous crystalline appearance. Durango; from my Cabinet, I, a and b.

2. Reniform, curved lamellar, the laminæ from 0.1 to 1^{mm} in thickness, separate on breaking with smooth surface slightly granular, brick-red; powder bright brick red. Coneto, State of Durango; from Mr. Joseph Wharton, II.

3. Large pebble, somewhat granular, of the appearance of compact hematite, powder brick-red. Durango; from Mr. Clarence S. Bement, III.

4. A mass which had deposited as an incrustation upon quartz or a siliceous rock, of a thickness of 20^{mm}, with fine crystalline fibrous structure, being flat on the bottom and reniform on the surface. Dark brown, a fresh fracture reddish brown, powder brownish brick-red. Coneto, State of Durango; from Mr. Joseph Wharton, IV.

5. Stalactitic, granular, the surface covered with minute crystals, color and powder bright brick-red. Minute crystals of hematite were implanted which were separated by a magnet (this hematite being slightly magnetic); from the ores No. 1 of Mina del Diablo, V.

6. Botryoidal, dark brown, on fracture paler reddish-brown, with a slightly fibrous structure; color of powder terra cotta; from Guanajuato, State of Guanajuato, from Mr. Clarence S. Bement, IV.

* *Artificial Pyrite.*—In the analysis it was found to be most convenient to render the cassiterite soluble by fusing with a mixture of sodium carbonate and sulphur, at first at a very low temperature, and then for about ten minutes at low red heat. There was rarely more than a few milligrams of cassiterite left unacted upon which yielded readily to a second fusion. Thus all the tin and arsenic, and the greater part of the iron dissolved in water as sulpho-salts of sodium. In two instances in Analyses III and V b, I was interrupted in my work and the fusion at a low temperature was continued for five or six hours. When the mass was treated with water it dissolved with a yellowish-red color without dark green tint, and the washings also did not indicate that any iron sodium sulphide had gone in solution. The insoluble residue, however, showed the iron in the form of octahedral crystals or clusters of crystals of pale brass-yellow *pyrite.*

	I. a	I. b	II.	III.	IV.	V. a	V. b	VI.
Sp. Gr.	= 6.820	— ——	— 6.591	— 6.911	— 6.535	— 6.714	— 6.712	— 6.581
SnO_2	= 92.54	— 92.84	— 93.98	— 93.01	— 92.09	— 86.99	— 86.81	— 92.26
Fe_2O_3	= 4.18	— 4.12	— 5.62	— 5.82	— 5.45	— 11.56	— 12.73	— 4.58
As_2O_5	= trace	— trace	— ——	— ——	— 2.11	— trace	— ——	— 1.25
CuO	= ——	— trace	— ——	— 0.07	— ——	— 0.11	— ——	— trace
ZnO	= ——	— ——	— ——	— ——	— ——	— ——	— ——	— 0.57
SiO_2	= lost	— 2.70	— 0.23	— 1.07	— 0.66	— 0.57	— 0.52	— 0.44
Ignition	= 0.38	— 0.34	— 0.24	— 0.27	— 0.07	— 0.20	— 0.34	— 0.26
		100.00	— 100.07	— 100.24	— 100.38	— 99.43	— 100.40	— 99.36

b. Yellow variety.—It occurs like the red in imitative shapes, and evidently has been formed under similar conditions.

The color is from a pale brownish-yellow, honey yellow to a reddish brown, sometimes greenish-yellow, variegated in bands of paler and darker colors. Globular, reniform, frequently curved lamellar, in many cases the laminæ readily separating. Several of the reniform masses from 25 to 35^{mm} in size are really stalactites which have formed upon some unknown irregularly-shaped substance which has weathered out, leaving a cavity, others are flat and have deposited upon quartz, of which some remnants may often be seen. Fibrous, radiating.

The most interesting and apparently purest specimens came from Mina Varosa; it is also associated with the red variety in the Placer ores No. 6, rarely in microscopic botryoidal concretions in the sand from Mr. Schlemm, and also in the ores of the San Antonio mine, forming about one-fifth of the whole mass.

The following analyses have been made:

1. Globular, radiating from the centre; powder cream color. Mina Varosa, State of Durango, VII, a and b.

2. Reniform and lamellar, concentrically fibrous; powder cream color. Mina Varosa, VIII.

3. Flat, brownish-yellow, banded, fibrous, radiating, powder dark cream color; from the Placer ores No. 6, IX.

4. Laminated, reniform, fibrous, brownish-yellow; powder brownish cream color; from Dr. Joseph Leidy, X.

	VII. a	VII. b	VIII.	IX.	X.
Sp. Gr.	= 6.160	— 6.219	— 6.509	— 6.199	— 6.496
SnO_2	= 84.20	— 84.30	— 92.50	— 89.90	— 93.13
Fe_2O_3	= 1.31	— 1.55	— 0.22	— 0.10	— 0.20
As_2O_5	= 9.85	— 10.34	— 4.56	— 5.80	— 3.18
CuO	= trace	— trace	— 0.16	— 0.20	— 0.09
ZnO	= 3.05	— 2.96	— 1.89	— 2.43	— 2.71
SiO_2	= 0.35	— 0.30	— 0.24	— 0.55	— 0.43
Ignition	= 0.39	— 0.57	— 0.26	— 0.40	— 0.32
	99.15	— 100.02	— 99.83	— 99.38	— 100.06

The analysis of the heavier portion of the ore from the San Antonio mine shows 3.86 per cent of dioxide of tin which went into solution by treating the same with chlorhydric acid. As cassiterite is not acted upon by acids, it is difficult to perceive in which form this tin existed. Dissolving in the presence of a neutral solution of auric chloride gave not a trace of reduced gold, therefore neither tin nor arsenic were in the form of the lower oxides.

There is a sufficient amount of arsenic pentoxide present to combine with all the bases; the lead is evidently in the form of mimetite of which the calculated percentage would be 12.58 per cent, the zinc is probably there as adamite, and the amount of zinc oxide found would give 6.96 per cent of this mineral; no arsenate of bismuth has yet been distinguished as a mineral, but there can be no doubt that the bismuth in the San Antonio ore is present as Bi_2O_3, As_2O_5, H_2O, the salt which Salkowski has first described and analyzed (Journ. für Praktische Chemie, 104, p. 172), the bismuth oxide found would give 7.94 per cent of the hydrous arsenate.

The insoluble portion of the San Antonio ore contains 19.300 per cent of SnO_2 and 1.844 per cent of arsenic pentoxide The atomic ratio between these would be = 16 : 1. To this I shall refer again further on.

The different varieties of cassiterite show a considerable variation in their specific gravity which, in part, is probably owing to cavities produced in the process of their formation. The arsenical varieties have all a lower specific gravity.

The analyses show that the red varieties are dioxide of tin, contaminated with ferric oxide, and only exceptionally containing an appreciable quantity of arsenic pentoxide, while the yellow varieties contain very little ferric oxide, but a far higher percentage of arsenic pentoxide and also invariably an admixture of zinc oxide.

It is difficult to perceive how these constituents in such variable quantities could be present in apparently perfectly pure and often highly crystalline minerals.

Excepting analysis V, in which the ferric oxide is double the amount of the average of the other analyses of the red varieties, which may be owing to the fact that the little crystals of hematite which have been observed being only slightly magnetic, were not completely separated by the magnet, they give the atomic ratio between $Fe_2O_3 : SnO_2 = 1 : 9$ and 1 : 12. Although the ferric oxide cannot be extracted from the stannic oxide by chlorhydric acid, I cannot favor the idea of a definite compound existing between these oxides, and consider them only as mechanical mixtures. The high percentage of arsenic pentoxide, especially in the apparently purest and highly crystalline globular variety from Mina Varosa, and the constant presence of zinc oxide are very surprising. It suggests the idea that there might be a zinc salt of one of the complex inorganic acids consisting of tin dioxide with arsenic pentoxide. A calculation of the molecular ratios of these constituents gave for :

Analysis	VII—	As_2O_5	:	SnO_2	:	ZnO	=	1	: 13	: 0.84
"	of San Antonio ore,						=	1	: 16	: ?
"	IX—	As_2O_5	:	SnO_2	:	ZnO	=	1	: 24	: 1.2
"	VIII—	"		"		"	=	1	: 31	: 1.1
"	X—	"		"		"	=	1	: 44	: 2.36
"	IV—	"		"		"	=	1	: 68	: ——
"	VI—	"		"		"	=	1	: 123	: 1.4

This shows no rational proportions in the constituents of the cassiterite, and there is no other conclusion than that both arsenic pentoxide, ferric oxide and zinc oxide are admixtures of the tin dioxide, which is easily explained, if we bear in mind the tendency of this latter substance which at the time of its formation, precipitated and retained these oxides.

c. Cassiterite, pseudomorphous after hematite.—It has already been stated that little red crystals of cassiterite are sometimes found associated with those of hematite. From the sands of Mr. Schlemm a few highly interesting, but unfortunately very small specimens were obtained.

One, about 1^{mm} in size, consists of perhaps a dozen modified crystals of hematite, with the basal plane predominating, in which latter twin groups of pseudohexagonal red cassiterite are implanted; the occurrence reminds one of rutil which frequently occurs in a similar manner upon the hematite (Eisenrose) from St. Gothard.

Another specimen consists of a group of tabular crystals, radiating from a centre, the whole group 3^{mm} in diameter, which is almost completely altered into reddish-brown brilliant cassiterite, leaving a small core of about 0.5^{mm} in size of unaltered hematite. About ten other pieces of the same kind, although far less perfect, have been observed.

d. Cassiterite, pseudomorphous after magnetite?—A little group of crystals from the ores of the Mina del Diablo— 5×3^{mm} in size, consists of crystals which are apparently isometric octahedrons, together with some botryoidal aggregations. The crystals are almost black, but mostly show an uneven surface, a color between brownish-yellow and yellowish-green and a waxy lustre, owing to a subsequent coating of reniform, botryoidal cassiterite upon the crystals. A fracture of the crystals shows the dark brownish-red color and lustre of the red cassiterite. The original mineral may have been magnetite. Only three of such minute groups have been found.

Of great interest in connection with these pseudomorphous forms of cassiterite are the observations of Mr. Wm. Semmons (published in London in the December number, 1883, of the Natural History Notes), who describes the coating of bismuthinite (Bi_2S_3) at the Fowey Consols Mine of Cornwall with thin layers of brownish cassiterite. In a letter dated London, August 19th, 1886, Mr. Semmons gives me fuller details about this occurrence as follows:

"The bismuthine (bismuthinite Dana) in this mine is found:

"1. As brilliant untarnished crystals.

"2. Crystals with a slight deposit of cassiterite on them.

"3. With the cassiterite coating the bismuthine in concentric layers, *wood tin*.

"All *wood tin*, the bismuthine having been carried away.

"You doubtless are familiar with the remarkable pseudomorphs of cassiterite after quartz which received for a short time the name of stannite "or silicate of tin from the late John Garby," &c., &c.

I should mention also the very interesting observation of microscopic crystals of cassiterite in the black zincblende of Freiberg, Saxony, described by Dr. A. W. Stelzner, and Dr. A. Schertel (Jahrbuch für Berg und Hüttenwesen im Königreich Sachsen auf das Jahr, 1886). The cassiterite in the variety "Nadelzinnerz" occurs associated with quartz crystals and sometimes implanted in the same, in minute and microscopic crystals and groups of crystals. Most of the forms are simple combinations of prisms and pyramids, and have no resemblance with the Mexican specimens. The whole occurrence indicates a simultaneous formation of the zincblende and cassiterite.

2. *Hematite.*

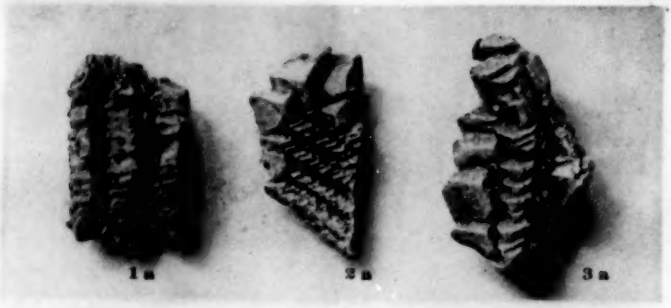
Both localities, the Mina del Diablo, and that in the Catatlan mountains from which the sands of Mr. Schlemm were obtained, furnished minute, sometimes very perfect, crystals of hematite, occasionally grouped in the form of "eisenrose." The crystals from Mina del Diablo are larger, at times from 2 to 3^{mm} in diameter and have the basal plane oR more fully developed.

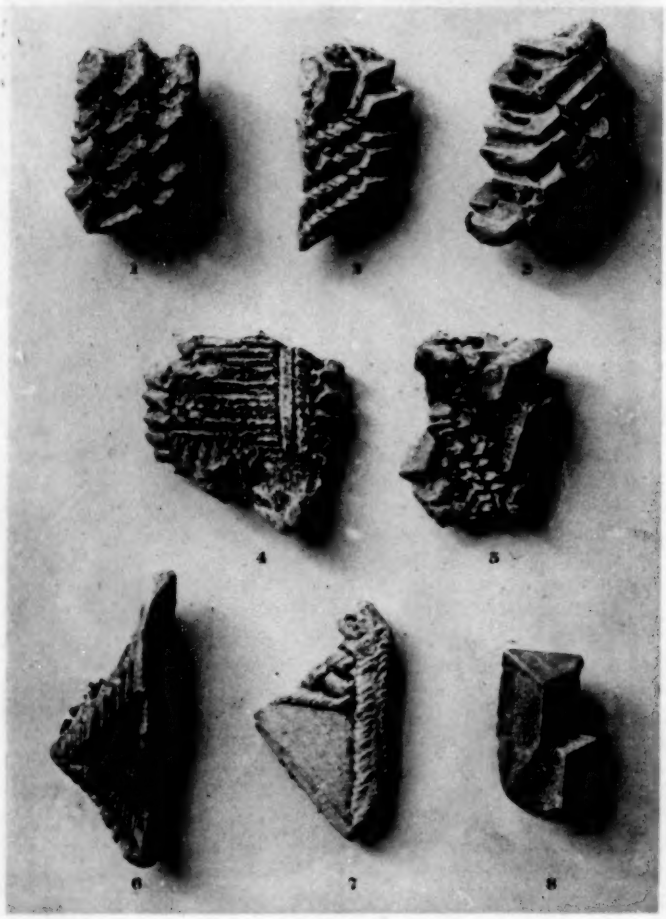
The crystals from the sands of Mr. Schlemm are very minute, and I am indebted to Prof. G. vom Rath for the following information:*

Contrary to the general rule these very minute crystals, from 0.25 to 1^{mm} in size show a holohedral development with the second hexagonal prism ∞P2, striated parallel to the basal edge, prominent. The second pyramid $\frac{2}{3}$P2 (π in Miller's mineralogy, π : oR = 137° 49′) dominates the polar development of these crystals. As combinations appear a more acute second pyramid $\frac{4}{5}$ P 2 (n in Miller, n : oR = 118° 53′), R and $-\frac{1}{2}$R. oR appears from a mere point to a relatively large extension. Ironblack, powder brownish-red; slightly magnetic.

As already mentioned under cassiterite, that hematite is sometimes found in part or wholly altered into cassiterite.

* I have sent to Prof. vom Rath the crystals of hematite, above referred to, also the peculiar pseudomorphous crystals with mimetite composition and the first specimens which I had received of the vanadinite and descloizite from Oracle, in Arizona. He has taken such an interest in these occurrences that he communicated the results of his investigations to the "Niederrheinische Gesellschaft für Natur und Heilkunde zu Bonn," at the meeting of January 11th, 1886, which have been published by this Society. In the following pages I shall refer to these communications, as l. c.





Mimetite Pseudomorphs.

Magnified two diameters.

EASTERLY PHOTOTYPE

3. Mimetite and Pseudomorphs of Mimetite after Anglesite?

The greater portion of the ores Nos. 1 and 2 from the Mina del Diablo consists of crystals and crystalline aggregations of a white or yellowish-white mineral, rough to the touch, somewhat earthy in appearance, with a slight resinous lustre on a fresh fracture. These crystals have been picked out from a great mass of clay and are a great rarity, and even the crystalline aggregations, which occurred in somewhat larger quantities, are completely exhausted. At the Mina de San Antonio, a few but far less perfect crystals have been observed.

a. Mimetite.—Small fragments of finely granular, frequently cavernous concretions, the surface of which is coated with microscopic colorless crystals, have been found among the above mentioned ores Nos. 1 and 2. Similar crystalline coatings are sometimes observed upon the crystals, especially when in groups, which were better protected against corroding influences, and it is most likely that the whole mass of the pseudomorphous crystals consists of an accumulation of such microscopic crystals, so small, however, that a fracture would show only a compact mineral with a slightly waxy lustre. Cavities of the pseudomorphous crystals are also sometimes lined with colorless microscopic crystals. It was very difficult to observe any distinct forms; when magnified 60 diameters many hexagonal planes were seen, but only one crystal was observed which showed a short hexagonal prism, with a second hexagonal prism, a pyramid and basal plane. Several others were found of the same form without the second hexagonal prism. These crystals have a vitreous lustre and are undoubtedly *mimetite.*

b. Pseudomorphs of Mimetite after Anglesite?—The great bulk of the ore, however, is entirely different and consists of pseudomorphs which have apparently a rhombic form while their composition is that of mimetite. They are associated with stalactitic or botryoidal red cassiterite often in isolated crystals with all planes fully developed, upon it, or in crystalline groups or incrusting the same. The whole occurrence shows the more recent origin of the mimetite pseudomorphs.

Isolated crystals are rare, they are often cavernous and generally arranged in reticulated and skeleton-like groups. On a most excellent phototype plate by Mr. Frederick Gutekunst, I have given a few of the forms magnified two diameters which show best this peculiar arrangement: 1a, 2a, and 3a are the reverse of 1, 2, and 3.

Measurements of the best isolated crystals gave angles which suggested the idea that the original mineral was anglesite.

I have submitted these crystals and aggregations to Prof. G. vom Rath, who had the kindness to make the following measurements, which, together with his conclusions, he communicated, l. c. On account of roughness and imperfection of the surfaces of the crystals only approximate measurements were possible, which were made with the help of attached glass plates.

Considering the crystals as a combination of a macrodome d with a brachydome o, the approximately measured angles d : d in axis c = 101° 30′ and 102° 30′ and o : o in axis a = 103° 30′, 104° 36′ and 105° 30′, a form which is very close to that of anglesite, if we compare d with $\frac{1}{2}\breve{P}\infty$ (101° 13′) and o with $\overset{2}{P}\infty$ (104° 24′).

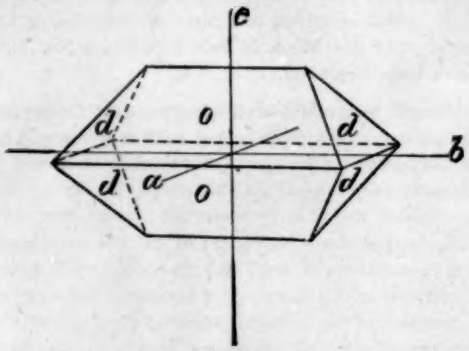


Fig. 9.

Prof. vom Rath is opposed to this view ; he would look upon it favorably if only isolated crystals had been observed, but would consider it very strange to find the skeleton-like formation and the reticulated arrangement of the aggregations in anglesite. He suggests that the primitive mineral might have been reticulated galenite, and he has been supported in this view by the late Prof. Websky, Prof. Descloizeaux and Dr. Hintze. Considering galenite as the primitive mineral, the apparently rhombic forms of these pseudomorphs would be distortions or irregular hemihedries of isometric forms, as it is well known how frequently galenite occurs in forms which have not the habitus of isometric crystals.

However, he was not able to reduce these oblongoctachedrons to normal planes of galenite, and notwithstanding the important opinions sustaining his views, Prof. vom Rath does not feel satisfied and expresses his manifest doubts by suggesting that, these forms might be pseudomorphs after a yet unknown rhombic mineral, having a tendency to occur in skeleton-like aggregations.

I have examined the reticulated galenite specimens in Mr. Clarence S. Bement's magnificent cabinet, but could not satisfy myself that the pseudomorphs under consideration could have resulted from such forms of galenite.

Reticulated galenite is of a rather rare occurrence, and such forms would not be known, if the few localities where it has been found would not furnish it. That anglesite has not been observed in such forms before, does not prove the non-existence of the same.

A suite of these pseudomorphous forms was sent by me to the Imperial

Mineral Cabinet in Vienna, and at my request, to give me his opinion, Dr. Aristides Brezina wrote me under date, Vienna, July 31, 1886:

"The pseudomorphs are evidently after mendipite* and permit to determine the heretofore incomplete elements of this mineral with a fair approximation:

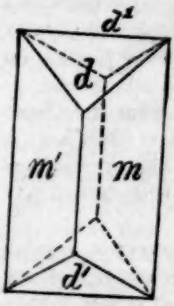


Fig. 10.

m : m′ = 77° 19′, mean of four measurements with the hand goniometer—mendipit measured 77° 24′.

d : d′ = 102° 23′, mean of four measurements with the hand goniometer—

from which it follows that the elements are rhombic.

$a : b : c = 0.8002 : 1 : 0.9948 \left(\frac{a}{c} = 0.8044\right)$ if m = (110); d = (101).

"At the same time the pseudotetragonal character is peculiar; the difference of the parameters b and c lies within the errors of observation, but the habitus of the crystals speaks for the rhombic system."

I thought it best to give these different views, trusting that the future may furnish, by the discovery of the unaltered mineral, together with the pseudomorphs, the true explanation of this doubtful subject.

The analysis of these pseudomorphs shows them to be mimetite in which a small quantity of the lead is substituted by calcium. Even the purest have an admixture of clay, containing a minute quantity of dioxide of tin.

Analyses 1 and 2 were made by myself with material selected from the best crystals and apparently quite pure, 3 and 4 were made by Mr. Harry F. Keller, with apparently pure crystals.

	1	2	3	4
Spec. Grav. =	6.636	6.611	———	———
Cl =	2.47	2.38	2.43	2.43
PbO =	71.40	71.27	70.63	70.56
CaO =	0.57	0.34	not determined	
As_2O_5 =	24.97	24.58	24.82	24.57
P_2O_5 =	0.05	not det'd	0.09	not det'd
Clay with trace of SnO_2 =	0.65	0.85	1.44	1.89
Ignition =	0.37	0.47	0.60	0.49
	100.48	99.89	100.01	99.94
Less O, equivalent to Cl =	0.56	0.53	0.55	0.55
	99.92	99.36	99.46	99.39

* I have just received a letter from Dr. A. Brezina, dated: Wien, April 7, 1887, in which he admits it as an oversight to have considered the mimetite pseudomorphs as being after *mendipite*, and states that there is now nothing to prevent the acceptance of my original views that the primitive mineral was *anglesite*. F. A. GENTH.

University of Pennsylvania, April 20, 1887.

II. Vanadinite and Descloizite.

a. Mr. Charles R. Fletcher, of Boston, formerly Superintendent of the Mammoth Gold mine, near Oracle, Pinal county, Arizona, sent me about two years ago a highly interesting and fine variety of vanadinite and descloizite and subsequently, from a new occurrence, he presented me with a number of magnificent specimens of the same minerals, which, as for vanadinite, are some of the finest which I have seen, for all of which I am greatly indebted to him.

Of the first lot received I sent a small piece to Prof. G. vom Rath, who describes it (*l. c.*) as being composed of barrel-shaped crystals with a brown nucleus, surrounded by a yellow coating of very fine aggregations of more recent growth, the druses and surfaces covered with exceedingly minute crystals of descloizite.

The vanadinite from this mine occurs upon quartz in crystals, varying in size from 0.1^{mm} to 8^{mm} in length, the smallest crystals are of a yellow color, which changes with their size increasing to an orange yellow, orange red, aurora red to a brownish-red, often variegated. Perfect isolated crystals are rare and generally small, they are mostly united to clusters and crystalline coatings upon the quartz; the crystals are often very much distorted and cavernous. The forms which I have been able to distinguish are the hexagonal prism with pyramid and basal plane, the latter frequently very small or entirely wanting.

Calcite sometimes surrounds the vanadinite and is again covered by vanadinite crystals.

b. A brownish-black and black descloizite from this locality covers in form of a crystalline coating in minute rhombic pyramids the reddish-white massive gold quartz, or is united to clusters of microscopic crystals upon and between the crystallized quartz. Upon these coatings of descloizite are the crystals of vanadinite, which again are covered with exceedingly minute crystals of descloizite. The yellow crystalline coating upon the brown nucleus, mentioned by vom Rath has often *no* nucleus of vanadinite, it is dull and of a yellow color throughout the mass of the hexagonal barrel-shaped crystals. Mr. H. F. Keller, who analyzed the brown and the bright orange red crystals from this locality (a, 1 and 2) found that the yellow mineral contains *no* chlorine. It is very probable therefore that the dull yellow crystals are pseudomorphs of descloizite after vanadinite.

Not enough of the descloizite could be obtained for analysis, qualitative tests however gave lead, zinc and traces of copper and manganese oxides with vanadium pentoxide.

c. A peculiar variety of vanadinite, much resembling pyromorphite, has been noticed in Yavapai county, Arizona, by Mr. J. C. Cooper, of Topeka, Kansas, who has sent specimens to the East. Mr. Clarence S. Bement kindly presented to me one, of which I have made the analysis

given below (c). The crystals occur as a coating upon porous quartz, are barrel-shaped prisms with basal plane, from very minute to not over 4^{mm} in size. Their color is from pale green to brownish olive green, small fragments are pale grayish green.

d. Mr. J. C. Cooper presented to me a small fragment of another variety from the same county. The crystals, not over 1^{mm} in size, are of brownish-red color, short hexagonal prisms with basal plane, on some a pyramid is slightly indicated. They cover a dark brown quartz. In some places is a very minute crystalline black coating upon the quartz, which may be descloizite.

e. A very interesting variety of a vanadate, which appears to be vanadinite, has been observed by Mr. J. C. Cooper, at the McGregor mine, Grant county, New Mexico. The specimen, for which I am indebted to him, consists of an impure, friable, earthy hematite, which is coated with crystallized calcite, frequently enveloping stalactites of the vanadium mineral, which is again covered by finely crystalline calcite. After removing the calcite by dilute acetic acid, the orange-yellow and orange-red stalactites remain. They are from 3 to 5^{mm} in length, and up to about 1^{mm} thick. When magnified 60 diameters, they show a core of some other mineral surrounded by scaly crystals of the vanadium mineral, the form of which could not be made out. A qualitative analysis showed lead oxide, vanadium pentoxide, and chlorine as the principal constituents, hence the conclusion that it may be vanadinite.

f. Prof. Albert H. Chester, of Hamilton College, N. Y., presented to me a few fragments of a yellow ferruginous quartz with a pale brownish crystalline coating, which appears to be descloizite, and upon it vanadinite in very minute crystals mixed with larger ones from 5 to 6^{mm} in length, and 0.5 to 1.5^{mm} in thickness, from Bald Mountain mine, Beaverhead Co., Montana. These crystals are hexagonal prisms with basal plane, some slightly barrel-shaped, the greater portion of the crystals is of a dark greenish-brownish color, their ends capped with almost transparent terminations.

g. In his Re-examination of American minerals, Am. Journ. Sc. [2], xx, 246, J. Lawrence Smith gives a description of vanadate of lead (descloizite?) from the Wheatley mines near Phœnixville, Pa., and an analysis of the same. He had only very impure material, mixed with a large percentage of wulfenite, etc., for examination, so that with the imperfect knowledge which we then (1855) had of descloizite, he expressed his doubt whether it was this species. I have examined a specimen which came from the late Mr. Charles M. Wheatley, at Phœnixville, and have no doubt of the correctness of Dr. Smith's determination.

Analyses of vanadinite. a, 1 and 2 by H. F. Keller; c by myself.

		a, 1. Brownish. From Mammoth		a, 2. Bright orange-red. Mine.		c. Brownish olive green from Yavapai County.
Sp. grav.	=	6.572	—	——	—	7.109
Cl	=	2.41	—	2.46	—	2.69
Fe_2O_3	=	0.48	—	——	—	0.04
CuO	=	——	—	——	—	0.18
PbO	=	77.49	—	77.47	—	77.96
V_2O_5	=	16.98	—	17.16	—	18.64
As_2O_5	=	3.06	—	4.30	—	trace
P_2O_5	=	0.29	—	trace	—	0.72
		100.71		101.39		100 23
Less O, equiv. to Cl.	=	0.55		0.56		0.61
		100.16		100.83		99.62

A. Variety of Descloizite, Cuprodescloizite, Ramirite, Tritochorite.— In 1883, Samuel L. Penfield (Am. Journ. Sc. [3] xxvi, 361) published the description and analyses of a mineral from Mexico as a variety of descloizite; at about the same time, C. Rammelsberg (Berl. Acad., Berl., 1883, 1215), under the name cuprodescloizite gave his analysis and description of the same mineral from San Luis Potosi in Mexico. In a pamphlet, "La Ramirita, nueva especie mineral, Mexico, 1885," D. Miguel Velasquez de Leon gave the same mineral the name ramirite, with an engraving showing its appearance and an analysis of the same.

In his paper Mr. Penfield referred to the great similarity of the appearance and the results of the analyses of his mineral with those of Frenzel's tritochorite. About two years ago Prof. F. W. Clarke presented to me a specimen of ramirite from San Luis Potosi, Mexico, and a year ago I had an opportunity to purchase, from Dr. A. E. Foote, a number of pieces which gave such an abundance of very pure material that I thought a re-examination desirable on account of great discrepancies in the amounts of water and the pentoxides of arsenic and vanadium as well as cupric oxide.

The mineral occurs as an incrustation from 1 or 2 to 10^{mm} in thickness, radiating fibrous to fine columnar. The form of the individual crystals cannot be distinguished, they are united into groups resembling the arrangement of cockscomb barite or prehnite. The color is dark yellowish-brown, and the surface has a dark color, and a velvety appearance; the fracture has a resinous lustre. Powder pale yellow. The spec. grav. = 6.203.

The analyses gave :

		1		2		3		Mean.	Ratio.	
Ignition	=	2.59	—	2.65	—	2.62	—	2.62	0.146	
PbO	=	54.89	—	54.35	—	54.31	—	54.52	0.244	
CuO	=	6.34	—	6.78	—	6.63	—	6.58	0.083	0.240
ZnO	=	12.70	—	12.84	—	12.56	—	12.70	0.157	
As_2O_5	=	3.63	—	3.57	—	3.70	—	3.63	0.016	0.125
V_2O_5	=	19.77	—	19.75	—	20.45	—	19.99	0.110	
P_2O_5	=	0.13	—	not determined			—	0.13	0.001	
		100.05						100.17		

For comparison I give the mean result of three analyses of Penfield, Rammelsberg's analysis of cuprodescloizite, Velasquez de Leon's analysis of ramirite and Frenzel's analysis of tritochorite.

		Genth.		Penfield.		Rammelsberg.		V. de Leon.		Frenzel.
H_2O	=	2.62	—	2.70	—	2.52	—	——	—	——
PbO	=	54.52	—	54.93	—	54.57	—	54.275	—	53.90
CuO	=	6.58	—	6.74	—	8.26	—	8.690	—	7.04
ZnO	=	12.70	—	12.24	—	12.75	—	11.250	—	11.06
As_2O_5	=	3.63	—	3.82	—	0.28	—	3.610	—	3.76
V_2O_5	=	19.99	—	18.95	—	22.47	—	19.850	—	24.41
P_2O_5	=	0.13	—	0.18	—	0.17	—	1.830	—	——
FeO	=	——	—	0.06	—	——	Mn_2O_3 =	0.150	—	——
		100.17	—	99.62	—	101.02	—	99.655	—	100.17

My analyses agree very closely with those of Mr. Penfield and give exactly the formula of descloizite Pb_2 [HO] (VAs P)O_4 + $(ZnCu)_2$ [HO] (VAsP)O_4.

In Rammelsberg's analysis the greater portion of arsenic pentoxide has evidently been weighed with the vanadium pentoxide.

In De Leon's analysis the determination of water is omitted, while otherwise the results agree with ours although the copper oxide is about two per cent higher.

The physical characters of the mineral and some of the determinations of the trichorite agree so closely to cuprodescloizite that it would be desirable if Dr. Frenzel would repeat his analysis.

III. Pyrite pseudomorphous after Pyrrhotite.

In a highly interesting and important paper on "Natural solutions of gold, cinnabar and associated sulphides, by Geo. F. Becker" (Am. Jour. Sciences [3] xxxiii, p. 199 ff), the author shows the solubility of gold, cinnabar, pyrite and other sulphides in alkaline solutions containing sulphydrates, and suggests that these minerals, found at Steamboat Springs and Sulphur Bank and similar occurrences, have been deposited from such solutions.

Several months before this paper appeared, Mr. John F. Blandy sent me from the mines near Sulphur creek, Colusa county, California, a number of specimens, containing gold in minute arborescent crystals, and crystalline coatings upon quartz and chalcedony in a dark gray shale from the mines at that locality, also cinnabar and pyrite, which evidently have been deposited under similar circumstances as those mentioned by Mr. Becker.

The pyrite is remarkable. It occurs in the same dark shale as the gold and appears in tabular hexagonal crystals, rarely reaching 1^{mm} in diameter. A few isolated crystals are very perfect, mostly however they are grouped together or one upon the other. Their color is pale brass yellow, they show very little lustre upon the basal plane, which is rather rough, but bright metallic lustre upon the prismatic planes.

A qualitative analysis showed them to be pyrite in composition, the form is that of pyrrhotite, they are therefore pyrite, pseudomorphous after pyrrhotite.

IV. Hessite.

An interesting variety of hessite has been found at the West Side mine, Tombstone, Cochise county, Arizona, and I am indebted to Mr. Samuel W. Cheyney for specimens for the same.

It is found in vein-like strings or patches in quartz, associated with cerargyrite in small crystals and crystalline coatings, a bluish green and a siskingreen mineral in too small a quantity for investigation, and minute grains of native gold. Color dark iron black; spec. gr. = 8.359.

Soluble in nitric acid without separation of gold.

In analysis 1, 0.61 p. c.; and in analysis 2, 3.98 p. c. of quartz were deducted, and gave:

		1		2
Ag	=	62.87	—	62.34
Pb	=	0.28	—	0.30
Fe	=	37.34	—	37.05
Se	=	trace	—	trace
		100.49	—	99.69

It is remarkable that no gold is combined with the tellurium, although metallic gold is associated with this hessite.

V. Tapalpite.

Prof. Carlos F. de Landero has given an account of the occurrence, the properties and the composition of tapalpite from the Sierra de Tapalpa (Boletin de la "Sociedad de Ingenieros" de Jalisco, Tom. v, Num. 3). From an analysis of it which Prof. C. Rammelsberg had made he came to the conclusion that the composition of this mineral is represented by the formula: $Ag_2 S. Bi_2 Te_2$.

This being exceedingly improbable, and a re-examination very desirable, Prof. C. F. de Landero has placed me under great obligations for spe-

cimens of this rare species, which have furnished the material for the following investigation:

It occurs at the San Antonio mine in the mineral district of San Rafael, Sierra de Tapalpa, Sayula Canton, State of Jalisco, Mexico.

It has a finely granular structure and a pale steel-gray color, inclining to lead-gray. Lustre dull metallic; soft.

Associated with pyrite, galenite, quartz and a silicate of aluminum and calcium, and so much intermixed with them that it was impossible to obtain pure material for analysis. The purest that could be selected was free from pyrite, but contained about 7 to 8 per cent of galenite and the same quantity of quartz and silicate. The specific gravity, which was found to be = 6.739, was approximately calculated for the pure mineral, and gave — 7.744.

Portions from two pieces, A and B, apparently equally pure, were analyzed. A by dissolving in nitric acid; B by fusion with sodium carbonate and sulphur—the sulphur in B was determined by fusion with sodium carbonate and nitrate, lixiviation with water and five times repeated evaporation with hydrochloric acid in order to reduce the telluri- to tellurous acid and precipitation of the sulphuric acid by barium chloride. The tellurium was always weighed as tellurous oxide.

The portion A gave:

		1		2		Average.		Ratio.		
Ag	=	38.81	—	38.36	—	38.59	—	0.357	=	3
Pb	=	7.22	—	7.26	—	7.24	—			
Bi	=	24.97	—	25.13	—	25.05	—	0.119	=	1
Cu	=	0.23	—	0.19	—	0.21	—			
Te	=	17.43	—	lost	—	17.43	—	0.136	=	1.15
S	=	7.93	—	8.54	—	8.24	—			
S required for 7.24 Pb to form PbS					=	1.12	—			
S in tapalpite					=	7.12	—	0.226	=	1.85

Ag : Bi : (TeS) = 0.357 : 0.119 : 0.362 = 3 : 1 : 3

= $Ag_3 Bi (STe)_3$ or $3 Ag_2 (STe)$. $Bi_2 (STe)_3$

The above average analysis and the atomic ratio of the constituents found give the following percentages:

Ag	=	43.76	—	6 Ag	=	648	=	43.76
Bi	=	28.41	—	2 Bi	=	420	=	28.36
Te	=	19.76	—	2.3 Te	=	294.4	=	19.88
S	=	8.07	—	3.7 S	=	118.4	=	8.00
		100.00				1480.8		100.00

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The portion B gave :

		1		2		3		Average.	Ratio.
Ag	=	39.54	—	39.34	—	39.35	—	39.41	0.365
Pb	=	6.13	—	6.28	—	6.25	—	6.22	
Bi	=	22.00	—	21.43	—	20.97	—	21.37	0.102
Cu	=	0.17	—	——	—	——	—		
Te	=	lost	—	18.53	—	18.53	—	18.53	0.145
S	=	7.16	—	——	—	——	—	7.16	
S required for 6.22 Pb to form PbS							=	0.96	
S in tapalpite							=	6.20	0.194

Ag : Bi : (TeS) = 0.365 : 0.102 : 0.339 = 3 : 0.84 : 0.93

This ratio makes it probable that the portion B had a slight admixture of telluride of silver.

Deducting galenite, &c., the analysis would give the following percentage :

Ag	=	46.09
Bi	=	24.99
Te	=	21.67
S	=	7.25
		100.00

Imperfect as these results may be on account of the noticed admixtures, there can be very little doubt that tapalpite is a normal sulpho-telluro-salt of silver and bismuth. Rammelsberg gives no lead in his analysis, and may have had purer material at his disposal ; it is to be hoped that such may be obtained for a subsequent investigation.

VI. Allanite.

A variety of allanite, closely resembling that from East Bradford, Chester county, Pa., and like the latter easily decomposed into a brown earthy powder, has been sent to me by Mr. J. A. D. Stephenson, who discovered it several years ago near Statesville, N. C.

The pure has a brownish-black color and a pitchy lustre. Associated with it are small zircons.

Mr. Harry F. Keller has made the following analysis :

Sp. Grav.	=	3.63
SiO_2	=	31.685
Al_2O_3	=	17.330
Fe_2O_3	=	7.052
Ce_2O_3, Di_2O_3, La_2O_3	=	18.990 { of which about 5 per cent Ce_2O_3, the rest mostly Di_2O_3.
Y_2O_3, Er_2O_3	=	1.120
FeO	=	10.110
MnO	=	1.025
CaO	=	10.785

MgO	=	0.540
Na_2O	=	0.210
K_2O	=	trace
H_2O	=	1.460
		100.307

VII. Willemite.

A few specimens of this rare mineral have been discovered by Mr. J. C. Cooper, of Topeka, Kansas, at the Merritt mine, Socorro county, New Mexico.

It occurs in very small hexagonal prisms, the largest not over 0.5^{mm} in size, associated with barite, quartz, mimetite, wulfenite, cerussite and a blue coating of a cupreous mineral. The willemite crystals are sometimes isolated, colorless, or black with a colorless top, mostly in coatings or ridges of aggregations of crystals filling cavities in the barite and quartz. They show only the prismatic and basal planes, the prismatic sometimes slightly striated longitudinally. In druses of quartz the microscopic willemite crystals are united to clusters, the individual crystals barrel-shaped, with deep longitudinal striation terminating in a serrated basal plane or in a point.

The mimetite, which is associated with the willemite, is of a bright honey yellow color, crystallized in slender hexagonal prisms with pyramid, often without the basal plane, also united to clusters, which, on breaking, present a radiating structure.

The wulfenite has a reddish-orange color, the crystals are tabular, and show pyramids of the first and second order.

It was difficult to obtain a sufficient amount of the willemite, and only by selecting a larger quantity of the purest material, and partial crushing and washing off the lighter particles and purifying the heavier by picking, I succeeded in getting enough to leave no doubt about the accuracy of the mineralogical determination.

The analyses gave:

		1		2
Spec. grav.	=	4.098	—	———
Barite	=	0.69	—	0.69
SiO_2	=	29.16	—	28.72
PbO	=	2.04	—	1.98
CuO	=	0.50	—	0.48
Fe_2O_3	=	0.10	—	0.04
Zno	=	66.79	—	66.59
Ignition	=	1.18	—	1.18
		100.46		99.68

Analysis 1 gave 91.53, and analysis 2, 91.18 per cent willemite. Lead and copper are probably present as carbonates.

VIII. Hisingerite, pseudomorphous after Calcite.

Many years ago the late Julius E. Raht, of Cleveland, Tennessee, sent me a suite of minerals from the Ducktown mines, which he was then working. Among them was a specimen composed principally of the ores of that mine, pyrrhotite and chalcopyrite with a small admixture of zoisite, which was covered with crystals of calcite, in part altered into a dark brown mineral with resinous lustre. The calcite is in the form of irregular hexagonal prisms, showing planes of a scalenohedron, the smaller ones terminating in acute scalenohedrons. The largest crystals are about 20^{mm} in length and 10^{mm} thick. They all contain a nucleus of unaltered calcite, the hisingerite surrounding the core of calcite is from 2 to 4^{mm} in thickness. With a small quantity (0.2236 grm.) of fairly pure material I made an analysis, the results of which show that the pseudomorphous mineral belongs probably to hisingerite, gillingite or thraulite, if they are not all more or less pure varieties of the same species.

The analysis gave:

Loss by ignition	=	23.70
SiO_2	=	24.42
Fe_2O_3	=	49.02
ZnO	=	1.17
CaO	=	1.83
MgO	=	0.41
		100.55

University of Pennsylvania, March 16, 1887.

Synopsis of the Batrachia and Reptilia obtained by H. H. Smith, in the Province of Mato Grosso, Brazil.

By E. D. Cope.

(*Read before the American Philosophical Society, March 18, 1887.*)

The Naturalist Brazilian Exploring Expedition commenced its work in the province of San Paolo. From the neighborhood of Sao Joao do Rio Negro a collection of Batrachia and Reptilia was forwarded to the writer, and a list of them was published in the Proceedings of this Society, 1884, p. 185.* Mr. Smith then went into the interior, crossing the mountains into the province of Mato Grosso to Cuyabá, on the headwaters of the Paraguay river. After a short sojourn at this town, he selected for resi-

* In this collection there occurs a species of Pseudis which I had identified with the *P. paradoxa*. In comparison with the type of the *P. mantidactyla* the specimens turn out to belong to that species, as supposed by Dr. Boulenger.

dence the village of Chupada, thirty miles north-east of Cuyabá, and near the headwaters of the Xingu, an important tributary of the Amazon. The species embraced in the following list were obtained at or near this town. I reserve any general remarks to the close of the paper.

BATRACHIA.

ANURA.

ARCIFERA.

1. BUFO MARGARITIFER Laur. Abundant.

2. SCYTOPIS ALLENII Cope. Proceeds. Amer. Philosoph. Soc., 1869, p. 162 Several specimens, representing a color variety, which lacks the lateral dark band.

3. HYLA MELANARGYREA, sp. nov.

Vomerine teeth in two small patches entirely between the choanæ, and scarcely reaching to the line of the posterior borders of the latter. Manus palmated to the discs of the third and fifth digits, but not to that of the third, and marking the basal third of the second ("first"). Pes webbed in much the same way; the web reaching the discs of the second, third and fifth digits, the middle of the penultimate of the first, and the base of the penultimate of the fourth.

The head is short, entering the length of the head and body, three and two-thirds times. Hind leg extended measuring the orbit with the heel. Hind foot short, equaling length of femur from groin. Fore-arm and foot, and tarsus and foot, with a free posterior edge, which has regular dermal thickenings, which give it a serrate appearance. The humerus is bound to the side by a dermal sheet which crosses the axilla to the middle of the posterior border of the former. Trace of a posterior dermal fold on the tarsus. No dermal process on the heel. Skin of upper surfaces with small scattered warts, which are most numerous and prominent on the sides. A pectoral fold from axilla to axilla.

The head is obtuse and depressed, with canthus rostralis not evident, and muzzle rather wide, and not prominent, but with vertical profile. Nostril terminal; side of muzzle as long as long diameter of orbit. Tympanic membrane round, three-fifths diameter of eye slit. Tongue subround, with an open notch posteriorly.

Color above, blackish gray, like a stain of dilute silver nitrate, with slightly darker areas included in darker lines. One of these is a large triangle whose base extends from one superciliary border to the other, and whose truncate apex is between the scapulæ: another is a large transverse area across the sacrum, which extends downwards and backwards on each side. Between these areas are several smaller ones on the back, and there is a large area on the side posterior to the axilla. An area encloses each canthus rostralis, enclosing with the large triangle a ⊥-shaped area of ground-color. There is a dark gray spot on the lip in front of the orbit, and a narrow one descending from the posterior part of the orbit. A dark

line extends from the orbit above the tympanic drum to the axilla. Posterior side of humerus and axillary web, black, the color produced in an angle towards the middle of the thorax on each side. Groin, femur except lower surface, inferior side of tibia and hind foot, anterior face of tarsus and web of inner three toes, pitchy black. A row of five or six small, silvery gray spots on the superior surface of the femur and surrounding the vent. With this exception, the superior surfaces of limbs light gray with darker gray cross-bands with black edges; three on the tibia.

	M.
Length head and body	.039
" " to posterior line of tympana	.0095
Width " at " " " "	.013
Length of anterior limb anteriorly	.0265
" " " foot	.011
" " posterior limb from groin	.0575
" " " foot	.026
" " " " without tarsus	.016

This species belongs to the same group as the *Hyla marmorata* in the general characters of skin and coloration. It is however of more slender form, and has less extensive palmation. The color differs in the absence of the yellow, which is so conspicuous in the *H. marmorata*, and in other respects.

Three individuals.

4. HYLA VELATA, sp. nov.

Size small; head short, wide, muzzle obtuse, not prominent, not long as the diameter of the eye. Nostril terminal. Tympanic membrane not very distinct, diameter not more than one-third that of the eye-slit, in some specimens one-fourth. Canthus rostralis not distinct, vomerine teeth between choanæ, not projecting posterior to the line connecting them. Tongue subround, with an open median notch behind.

The length of the head to the line connecting the posterior borders of the tympanic membranes, is contained in that of the head and body three and a half times. The hind leg when extended marks the end of the muzzle with the heel. The skin of the upper surfaces is smooth. An extension of the skin of the sides binds the humerus by its proximal half. There is a web between all the fingers which does not reach the discs of the third and fifth, being less than a half palmation. The web of the pes does not quite reach the discs of the digits excepting the fourth, where it leaves two and a half phalanges free. No dermal fold on the tibia or fore-arm.

Color above golden-brown, with a large patch finely dusted with dark brown, with a narrow dark-brown border, extending from between the eyes to the middle of the back, and sending a broad branch down to the middle of each side without defined inferior border. The outlines are con-

tracted at the suprascapular region, leaving a wide band of the paler ground color between it and a black line posterior to the eye. A very convex crescent-shaped area extends forwards from the posterior parts of the iliac region on each side, presenting a convexity forwards on the sacrum. Lips, sides, humerus and femur thickly dusted with brown, and without other spots or marks. Fore-arm and tibia with dark-brown cross-bars; on the latter narrow, and four in number. A pale border on external edge of foot from heel. Inferior surfaces cream-colored, immaculate.

	M.
Length of head and body	.023
" " " to posterior line of tympana	.0068
Width " " at " " " "	.0084
Length of fore leg	.014
" " " foot	.006
" " hind leg	.0385
" " " foot	.017
" " " " less tarsus	.009

There is a good deal of affinity between this species and the last. The differences are as follows: In *H. velata* the posterior legs are longer, and the manus is less palmate. There are no dermal borders on the limbs. The femur is unspotted, and the black color so conspicuous in the *H. melanargyrea* is absent. The dimensions are strikingly different, the species just named having nearly twice the linear measurements of the *H. velata*.

Four specimens.

5. HYLA NIGRA, sp. nov.

Habit moderately slender; heel reaching end of muzzle. Length of head to posterior borders of tympana, enters length of head and body three times. The urostyle and pelvis are rather short, the former equaling the length of the head to the line of the posterior border of the orbits. The muzzle is slightly acuminate when viewed from above, and projecting beyond the mouth in profile. The canthus rostralis is concave, and the orbit is just as long as the muzzle. Nostrils subterminal. Tympanic drum round, one-fourth the diameter of the orbit, and bounded above by a dermal fold. Vomerine teeth in two fasciculi between the nares, their posterior edges a very little behind the borders of the latter. Tongue subround, with an open notch in the free border.

Digits of manus entirely free; the fourth quite long, and the fifth exceeding the third in length. Second digit opposed to third. Dilatation of fourth digit just fitting within border of tympanic disc. Toes webbed to the dilatations of the second, third and fifth digits, and to the base of the antepenultimate phalange of the fourth and first.

Skin with numerous short longitudinal and not very prominent warts on the superior surfaces of the head and body. No distinct axillary membrane.

Superior surfaces uniform black. Gular region, inferior surface of

thigh and tarsus dusted with dark brown. Posterior part of side, front and hind face of femur and inferior face of tibia, more or less closely marbled with brown on a white ground, the brown predominating on the posterior face of the femur. The brown dusting extends across the inferior surface just behind the axillæ. Concealed surface of pes and web, marbled dark brown and white. The coloration is peculiar in that the superior surfaces of the humerus and tibia are colored like the rest of the body.

	M.
Length of head and body	.034
" " " to posterior line of tympana	.010
Width " " at " " " "	.013
Length of fore leg, on front	.022
" " " foot	.011
" " hind leg, from groin	.057
" " " foot	.026
" " " " minus tarsus	.010

This species approaches the genus Scytopis in the very narrow fronto-parietal frontanelle.

6. HYPSIBOAS BOANS Daudin.

One specimen rather smaller than usual. The femur is brown posteriorly, with small scattered yellow spots.

7. HYLODES CONSPICILLATUS Günther.

Hylodes guentheri Steindachner. Verh. Zool. Bot. Gess. Wien., 1864, p. 246, Pl. xvii, fig. 1.

Numerous individuals, all with the posterior face of the femur unicolor.

8. PALUDICOLA NATTERERI Steind.

A very abundant species, always without tarsal spur as described by Steindachner. The lumbar gland is black with a white border, and the groin below it and the posterior face of the femur is beautifully marbled with black on a white ground. Vomerine teeth none. Tongue subcylindric.

9. PALUDICOLA KROYERI R. & L. *Liuperus sagittifer* Steind.

Three specimens, two with the oblique longitudinal bands described by Steindachner, and the other unicolor above, having only the black lateral band extending from the end of the muzzle.

10. PALUDICOLA SALTICA, sp. nov.

Characterized by the great length of its posterior legs. It has the form of the North American Acris, and is probably like it, a great jumper.

Muzzle narrowly acuminate, and projecting a little beyond the lip-border. No canthus rostralis; nostril looking partly upwards, half way between end of muzzle and orbit. Interorbital space not wider than eyelid. Tym-

panic membrane not distinguished. Tongue diamond-shaped with rounded angles, extensively free and entire behind. No vomerine teeth.

Hind legs long; when extended the muzzle marks a little beyond the middle of the tibia. Second finger shorter than third. Toes with a dermal margin. Two metatarsal tubercles, both small, the internal larger and subconical, and giving origin to a dermal fold which extends to the middle of the tarsus. No tarsal tubercle. Skin of upper surfaces and sides with numerous small warts. Inferior surfaces smooth.

Color of adult dark-brown on superior and lateral surfaces, of younger individuals gray. The median dorsal region is marked with a wide black or dark-gray tract with undulating borders from between the eyes to the end of the urostyle, and this is again divided in many specimens by a median white band which extends from the vent to the end of the muzzle. In the adult the femur has one, and the tibia has two blackish cross-bands, and the superior edge of the tibia is pale-colored on its distal fourth. Posterior face of femur, and superior face of humerus, pale-brown. Posterior foot with numerous brown cross-bands. Below white (inferior surfaces of hind legs possibly yellow in life); the lower lip black all round, the color advancing towards the throat on each side. This mark is present on all the specimens.

	M.
Length of head and body	.020
" " " to posterior line of tympana	.007
Width " " at " " " "	.007
Length of fore limb	.012
" " " foot	.005
" " hind limb from groin	.0413
" " " foot	.020
" " " " without tarsus	.013

One adult and several young specimens. Readily distinguished by its very long hind legs, peculiarly shaped head, etc.

11. PALUDICOLA MYSTACALIS, sp. nov.

Size small. Heel of extended hind leg reaching to front of orbit.

Muzzle a narrow oval as viewed from above, a little longer than the diameter of the orbit, and not projecting beyond the lip-border. Canthus rostralis indistinct. Interorbital space wider than eyelid. Gape of mouth wide. Tongue narrow, extensively free, entire behind. Nostrils two-fifths way from end of muzzle to orbit. Tympanic disc concealed. Second finger ("first") shorter than third, which is in turn a little shorter than fifth. Two large palmar tubercles. Terminal phalanges not shorter nor expanded at the extremities, but obtuse. The close contact of the third, fourth and fifth metatarsals gives the foot a narrow form, especially as the first and second digits are short. The other digits, especially the fourth, are quite slender, with elongate narrowed terminal phalanges as in Lepto-

dactylus. No dermal margins. Skin generally smooth; no discoidal ventral fold.

Color of superior surfaces and sides, black. A broad white band extends from each eye to the groin; it is distinct in the young, obscure in the adult. It is bounded below by a black band which widens near the axilla. A white line extends on the middle line from the extremity of the muzzle near the end of the urostyle. In the young it sends off a little branch on each side to the eyelid. The upper lip is marked as follows: A white vertical bar marks the middle of the premaxilla; two bars are below the nostril, and two larger ones below the eye. A short distance behind the latter a white stripe commences and extends to the axilla. The superior face of the femur is pale longitudinally; the posterior face is brown, with a pale longitudinal band in the centre. Under surfaces white, except that the throat and breast are faintly brown spotted. The femora are similarly brown spotted in an oblique tract from the anus to the anterior aspect of the knee.

	M.
Length of head and body	.0172
" " " to line of tympana	.0057
Width " " at " " "	.0052
Length of anterior limb	.009
" " " foot	.0047
" " posterior leg from groin	.0267
" " " foot	.0135
" " " " minus tarsus	.009

But three specimens of this species was obtained by Mr. Smith, and these are of small size. All their parts are, however, fully ossified, and its characters developed.

13. PALUDICOLA AMEGHINI, sp. nov.

No lumbar gland nor tarsal tubercle, nor vomerine teeth. Skin covered with large flat warts irregularly arranged.

Muzzle short and acuminate; no canthus rostralis; muzzle not projecting in profile. Nostril half way between its extremity and the orbit. No membranum tympani. Interorbital space a little wider than eyelid. Second finger shorter than third. Extended hind limb reaching with the heel half way between orbit and nostril. Two metatarsal tubercles small but distinct, a diagonal fold extending from the internal to the middle of the tarsus. Toes with narrow dermal margins, and a short web at the base. Soles smooth. General form robust.

Color of superior surfaces and sides, a lighter or darker lead-color. There is a dark band extending from one superciliary border to the other, and there are indirect cross-bands on the hind legs. Very indistinct light bars on upper lip. Below white, the border of the lower jaw densely marbled with blackish. Posterior face of femur dark, with a longitudinal pale line near the inferior side.

	M.
Length of head and body	.0155
" " " to line (posterior) of tympana	.0055
Width " " at " " " "	.005
Length of anterior leg	.009
" " " foot	.004
" " posterior leg	.0258
" " " foot	.012
" " " " less tarsus	.008

This species belongs to the group of *P. marmorata* of Boulenger's system. Two specimens.

Dedicated to my friend Dr. Florentine Ameghino, the distinguished naturalist of Buenos Ayres.

13. LEPTODACTYLUS GRACILIS D. & B.

One rather large individual.

14. LEPTODACTYLUS BREVIPES, sp. nov.

Form rather stout, legs short. The heel of the extended hind leg reaches to the middle of the orbit, and the foot is as long as the rest of the leg measured to the groin.

The outline of the head from above is an acuminate oval. The muzzle projects a little beyond the lip when viewed in profile. The top of the head is flat, but the canthus rostralis is so obtuse as to be scarcely noticeable. The nostril is almost terminal, and as far from the orbit as the diameter of the latter. The tympanic membrane is round, and is equal to two-thirds the orbit in diameter. The vomerine teeth are in two short, nearly transverse patches, well behind the internareal palatal space. The tongue is a wide oval, slightly emarginate behind.

The second, fourth and fifth fingers are equal in length. The toes contract to their extremities, and have a membranous border on each side and a rudimental web at the base. The external border of the external toe is continued along the external edge of the sole of the calcaneum, terminating near a small, round tubercle. The internal tarsal tubercle is an oval, attached by one side. There is an obtuse dermal ridge extending along the inner edge of the tarsus.

There is a strong dermal fold above the tympanic membrane, which is deflected towards the humerus. Another ridge extends from the eyelid to above the axilla. Another ridge commences a short distance from the end of the last mentioned, and ceases just above the groin. Skin of superior surfaces with numerous small warts, below, except adjacent parts of femora, smooth. A discoidal fold of abdominal integument. All the ridges and warts of the upper surface might readily disappear on prolonged preservation in weak alcohol.

The color of the upper surfaces is a blackish brown, which does not extend on the sides, but forms a dark band from the eye through the tympanum to near the shoulder. There is a paler band across the front

between the eyelids, bounded posteriorly by the base of an indistinct dark triangle, which is darker than the rest of the back. The lips are clouded, and there is a vertical pale line on the end of the muzzle, and a similar one on each side of it below each nostril. The ground color of the legs is gray. The humerus is uniformly pale, but the fore-arm is blackish speckled. There are four wide blackish cross-bands on the femur, and three on the tibia. Femur behind closely marbled with black on a dirty whitish ground. Inferior surfaces straw-color, with indistinct brown speckles on inferior face of tibia, femur, and lower jaw. The sole is blackish from the heel, and there are five blackish cross-bands on the outside of the foot. Groin marbled with black, and a few shades in the axilla.

	M.
Length of head and body	.054
" " " to posterior line of tympana	.015
Width " " at " " " "	.020
Length of fore leg	.025
" " " foot	.011
" " hind leg from groin	.074
" " " foot	.031
" " " " less tarsus	.024

Though allied in important characters to the *L.* (*Crossodactylus*) *gaudichaudii*, the differences are numerous, to judge from the description given by Boulenger (Catal. Bat. Sal. B. M., p. 249). The well-developed vomerine teeth, the terminal nostril, the weak tarsal tubercles and the ventral discoidal fold are some of these.

One specimen.

15. LEPTODACTYLUS GLANDULOSUS, sp. nov.

Small; extended hind leg reaching middle of eye. Toes without dermal margins. Vomerine teeth in two transverse fascicles well behind the line connecting the choanæ.

Muzzle narrowed, somewhat prominent, rounded transversely and without distinct canthus rostralis. Nostril two-fifths the distance from the extremity of the muzzle to the eye. Tongue oval, entire posteriorly. Tympanic drum one-half diameter of eye-slit. First finger not longer than second. Metatarsal tubercles two, both very small. Palm and sole tubercular, the latter rough with pointed warts. Interorbital width equal that of eyelid. Skin smooth, excepting two rows of glands or glandular warts, one on the upper part of the side, extending from above the humerus to the groin, and the other above it, which terminates in a number of low warts on the posterior iliac region. Numerous similar warts on the side below the inferior glandular ridge. A groove from the eye above the tympanum towards the humerus bounds the lower side of a glandular dermal thickening.

Color blackish, dark-brown, or light-brown above, with a median

whitish line which is wanting from the anterior part of the body or head. The lighter specimens have numerous dark-brown spots on the lighter ground above. Several light vertical lines on the lip. Femur behind obscurely and finely marbled. The concealed edge of the tibia and tarsus dark cross-banded on a light ground. Below dirty white, dusted with brown on the legs, sides and gular region, and frequently on the abdomen also.

	M.
Length of head and body	.024
" " " to posterior line of tympana	.0075
Width " " at " " " "	.0082
Length of fore leg	.0115
" " " foot	.0045
" " hind leg from groin	.032
" " " foot	.0155
" " " " minus tarsus	.0102

Fourteen specimens.

FIRMISTERNIA.

16. ENGYSTOMA OVALE Schn.

17. DENDROBATES BRACCATUS, sp. nov.

Small. Second digit of manus ("first") much longer than third ("second"). Skin tubercular. Muzzle overhanging lip, but not much produced, truncate on superior view, about as long as diameter of orbit. Nostril nearly terminal. Tympanic disc less than half diameter of eye. Interorbital space much wider than eyelids. Tongue cylindric, entire. When the fore leg is extended, the muzzle marks the middle of the forearm. The muzzle marks the heel of the extended hind leg. Digital expansions of foot smaller than tympanum, and larger than expansions of fingers. The tuberosities of the upper surfaces are not prominent and in a soft specimen they have disappeared entirely. Skin of back very porous; no distinct glandular folds.

Black above, with a white line extending from one groin to the other, over the tympanic drum, on the edge of the eyelid, and round the end of the muzzle. Sides of head and body black; a narrow white line commencing below the nostril and extending to the humerus. Behind the humerus a large pink spot, followed by a wide irregular light band to the groin. A large pink spot in the groin and extending over the adjacent part of the femur. This spot is sometimes obscured by dark bands running across it. Limbs dark colored above, the posterior face of the femur similar, sometimes a bright spot under the knee. Under side of tibia with pink areas enclosed by black boundaries. Borders of abdomen and front of femur with small black dots. In some specimens there is a trace of two pale lines on the back about equidistant from each other and from the superior lateral lines.

	M.
Length of head and body	.022
" " " to posterior edges of tympana	.007
Width " " at " " " "	.007
Length of fore leg	.014
" " " foot	.006
" " hind leg	.0305
" " " foot	.015
" " " " less tarsus	.0098

This species agrees in most of its characters with the *D trivittatus* Spix., but is very much smaller, not measuring half its linear dimensions. As the specimens are, according to Mr. Smith, adult, they must be regarded as specifically distinct. It is also related to the *D. hahneli* of Boulenger,* but differs in the considerably shorter posterior limbs.

The singular manner in which this species carries its larvæ is described by Mr. Smith in the American Naturalist, for April, 1887. The latter are carried, closely packed, embedded in a coating of gelatine, on the back of the parent. This constitutes a method of nursing distinct from any of those enumerated by Mr. Boulenger in his recently published table.

It approaches nearest the habit of the *Pipa monstrosa*, which also carries the young on the back. But, as is well known, the skin itself and not a gelatinous secretion, encloses the eggs and retains the young until the metamorphosis is complete in that species.

Several larvæ accompany one of the specimens of this species, which are stated by Mr. Smith to have been adhering to its back when it was taken. They do not resemble those of Pipa, but rather those of a Rana or Bufo. The branchial opening is on the left side, and no limbs are developed. The tail is long. The mouth is not peculiar. The decurved lower lip is present, and is furnished with two transverse series of bristle-teeth. A single series of the same extends entirely across the superior labial region, above the upper horny jaw. The papillæ are rather long, and extend all round the inferior lip, and for a short distance on each side at the lateral end of the upper lip; the series presenting an entering angle opposite the mouth.

This species is described and figured† by Steindachner in the Verhandl. der k. k. Zoolog. Botan. Ges. in Vienna, 1864, p. 258, who refers it to the *D. trivittitus* ("*nigerrimus*"), under the impression that the specimens before him are not adult. He states that the latter were labeled *Dendrobates braccatus*, by Dr. Fitzinger. This name is not adopted by Steindachner, but I use it in order not to simplify the synonymy.

18. PROSTHERAPIS BRUNNEUS, sp. nov.

Viewed from above the end of the muzzle is rounded, but it is angulated at the nostrils. In profile it is vertical, as is also the loreal region.

* Proceeds. Zoöl. Soc. London, 1883, p. 636. Pl. lvii, fig. 4.
† Plate xiii, fig. 2.

Canthus rostralis obtuse. Muzzle longer than diameter of orbit; nostril marking two-fifths distance from ear to orbit. Interorbital space wider than eyelid. Tympanum concealed. Tongue obovate, extensively free and entire behind.

Digital enlargements distinct; two metatarsal tubercles small and subequal. Second ("first") finger equal to second. Skin with numerous small low glandular warts, easily obscured by stretching. The heel of the extended hind leg reaches the front of the eye.

Color of superior and lateral surfaces brown; a darker brown tract commences between the eyes and extends to the middle or end of the urostyle, with contractions of width on the nape and in front of the sacrum. A nearly black band extends round the end of the muzzle on the side of the head and body to the groin. Only one, a wide brown band across femur, between which and the anal region is a pale space. The inner edge of the band becomes a blackish spot in front near the groin. One brown band across tibia; several bands on tarsus. Femur brown with many light points posteriorly. Inferior surfaces unspotted white.

	M.
Length of head and body	.019
" " " to line of tympana	.006
Width " " at " " "	.006
Length of anterior leg	.0108
" " " foot	.004
" " posterior leg from groin	.0265
" " " foot	.0125
" " " " minus tarsus	.0074

Numerous specimens, mostly young.

The discovery of this species is of much interest, as it gives the genus Prostherapis a continental distribution. First detected in the extreme north-west of the Colombian district, it has been identified by Boulenger next from Ecquador,* and later from northern Peru.† To the present time the latter is the most eastern locality known for it.

LACERTILIA.

19. Anolis fuscoauratus D. & B. One specimen.
20. Anolis binotatus Peters; Boulenger, Catalogue. Abundant.
21. Polychrus acutirostris Spix. Abundant.
22. Scartiscus caducus Cope. Two specimens.
23. Microlophus spinulosus Cope. Abundant.
24. Ecphymotes torquatus Spix. Not rare.
25. Hoplocercus spinosus Fitz. One specimen.
26. Tupinambis teguexin L.
27. Ameiva surinamensis L. Abundant.

* Catl. Batr. Sal., Brit. Mus., 1882.
† Proc. Zoöl. Soc. London, 1883, p. 635.

28. CNEMIDOPHORUS OCELLIFER Spix. Three.
29. PANTODACTYLUS SCHREIBERSII Wiegm. Two.
30. CERCOSAURA OCCELATA Wagl. One.
31. EMŒA FRENATA Cope. Abundant.
32. AMPHISBÆNA ALBA L. Abundant.
33. LEPIDOSTERNUM MICROCEPHALUM Wagl.

OPHIDIA.

TORTRICINA.

34. TORTRIX SCYTALE L.

ASINEA.

35. BOA CONSTRICTOR L.
36. APOSTOLEPIS ERYTHRONOTUS Peters; *Elapomorphus erythronotus* Peters, Monatsberichte K. Akad. Wiss., Berlin, 1880, 222.

Subspecies LINEATUS Cope.

This form agrees exactly in pholidosis with Peters' description, above cited, of specimens from San Paolo, but differs much in coloration. It presents five longitudinal brown lines on the upper surface which mark the third and fourth, the fifth and sixth, and the median rows of scales respectively. In the adult, the line on the fifth and sixth rows is obsolete. The inferior surfaces are immaculate, except that the black collar is visible on the sides of the neck, from below. In the form *erythronotus*, the gastrosteges have black centres, according to Peters.

37. RHYNCHONYX AMBINIGER Peters, Monatsber. Berlin Akad. Wiss., 1869, p. 437.

Subspecies VITTATUS Cope.

This form differs from the typical form described by Peters, in having longitudinal color bands. These are dark-brown, and are located on the fourth, sixth and median rows of scales respectively, occupying only the middle of each row. The space between the sixth rows of opposite sides is pale brown; external to the sixth row and below, dirty white. The entire coloration is so like that of the young of *Apostolepis erythronotus lineatus*, as to be a case of mimetic analogy.

The present specimen confirms the correctness of the locality given by Peters.

38. TANTILLA PALLIDA, sp. nov.

Postocular plates two, labials seven, the posterior elevated and separated from the parietal by one and a part of another temporal. Postnasal and preocular plates well separated.

Characters normal. Postnasal bounded below by first labial, behind by second labial, which reaches frontal. Preocular deeper than long. Third and fourth labials bounding orbit, the latter also bounding inferior postocular below. Fifth labial higher than wide; the sixth of equal height, which equals the middle; the seventh largest of all, a little higher than wide (or long). A large temporal bounds the fifth and sixth above, and a

narrower one the seventh above, by its anterior third. Inferior labials seven, the fourth much the largest; the first of opposite sides separated by the symphyseal. Postgenecials shorter than pregenecials. Frontal with produced posterior angle; parietals elongate. Gastrosteges 148; anal 1–1; urosteges 57.

Color very pale brown above, white below. Top of head black; a broad black collar incomplete below, and connected with the head color on the middle line. A white spot on labial below nostril; another below and behind orbit, which extends to the last superior labial, and connects with the pale collar. Edges of scales on sides, brown-dusted.

Total length 285; of tail 65mm., or a little less than one-fourth the total. One specimen.

39. RHADINÆA OCCIPITALIS Jan. *Enicognathus occipitalis* Jan., Iconogr. Gen. des Ophidiens Livr., 16; Pl. 1, fig. 1. Two specimens.

40. APOROPHIS ALMADENSIS Wagl. Abundant.

41. OPHEOMORPHUS BRACHYURUS, sp. nov.

Form robust, tail remarkably short, constituting less than one-sixth the total length. Head wider than the neck, muzzle rather short.

Rostral plate rounded, visible from above. Internasals as long as prefrontals, the median sutures of both not continuous, but each oblique to the middle line. Frontal narrowing behind; the parietals not longer than the frontal, emarginate at the point of union posteriorly. Loreal plate much higher than long. Preocular narrow, not or barely reaching frontal. Postoculars two, the inferiors quite small. Temporals 1–2. Superior labials eight; the third narrowed; fourth and fifth entering orbit; the last three large, the seventh higher than long. Inferior labials ten, sixth largest. Genials unequal, the posterior pair short. Scales small, poreless, in 19 longitudinal rows. Gastrosteges 153; anal 1–1; urosteges 39. Measurements, No. 1, total length 371mm.; tail 55mm.; No, 2, total 435 mm.; tail 67mm.

Color, above bright green; below pale yellow. No markings. On the superior labial plates the green and yellow pass into each other.

This species is allied to the *Opheomorphus typhlus*, but has a relatively much shorter tail. It is a much more robust snake than the *O. jægeri* and it does not possess the brown dorsal stripe of the latter.

Two specimens.

42. OPHEOMORPHUS MELEAGRIS Shaw; subsp. DOLIATUS Wied.

A large specimen in the which the black annuli are so wide as to nearly meet on the dorsal region, leaving only traces of the ground color between them. I have often had occasion to observe that this annulate coloration characterizes adults as well as young.

43. LIOPHIS REGINÆ L., var. with unicolor parietals.

44. ERYTHROLAMPRUS VENUSTISSIMUS Wied.

45. DIPSAS CENCHOA Linn.

46. SIBON ANNULATUM Linn.

PROC. AMER. PHILOS. SOC. XXIV. 125. H. PRINTED APRIL 28, 1887.

47. TACHYMENIS STRIGATUS Gthr. *Tomodon strigatus* Günther; *Tachymenis hypoconia* Cope, teste Boulenger.
48. OXYRRHOPUS TRIGEMINUS D. & B.
49. OXYRRHOPUS RHOMBIFER D. & B.
50. OXYRRHOPUS PETALARIUS Linn.
51. LEPTOGNATHUS TURGIDA Cope; var. in which the top of the head is uniform blackish.
52. SPILOTES CORAÏS Linn.
53. HERPETODRYAS CARINATUS L. Abundant.
54. DRYMOBIUS PANTHERINUS Merrem.
55. DIRRHOX LATIVITTATUS, sp. nov.

The generic name Dirrhox is proposed as a substitute for Callirhinus Girard, a name used by Cuvier for a genus of seals. The type is *Dirrhox patagoniensis* Girard, which is described in the report of the U. S. Exploring Expedition under Commodore Wilkes (1858, p. 139). It is a terrestrial form of Philodryas with two loreal plates one above the other. The name was first proposed in my catalogue of the Batrachia and Reptilia of Central America and Mexico, Bulletin U. S. Nat. Museum, No. 32, 1887, Index. At the same time (l. c.) I propose the generic name Atomophis for the *Philodryas trilineatus* of Burmeister (*Dryophylax burmeisteri* Jan.), in which the loreal plate is wanting.

The *Dirrhox lativittatus* is a handsome species of moderately slender proportions, and with the head little distinct from the body. The scales are in nineteen longitudinal series, and each has a single apical pit. Muzzle rather narrow, rounded and not truncate, the apex of the rostral plate appearing on a view from above. The internasals are as wide as long, and the prefrontals a little longer than wide. The frontal has concave lateral borders, and is about as wide as the superciliaries, and as long as the occipitals. The nasals are subequal, and the loreals are placed the one directly above the other. The inferior is parallelogrammic and horizontal, while the superior is shorter and a little higher behind than before. The oculars are 1–2. The preocular is much wider above than below, and reaches the frontal. The superior postocular is larger than the inferior. The temporals are 1–2–3. The superior labials are eight in number, the fourth and fifth forming the inferior boundary of the orbit. Inferior labials eleven, the sixth largest, and in contact with the postgenials, which latter are a little longer than the pregenials. Gastrosteges 184; anal divided; urosteges 82.

The ground color above is a pale brown, which changes to olivaceous on the head. A narrow black line passes from the eye along the superior edges of the posterior labial plates, and immediately behind them widens out into a brown band, which soon occupies three and two half rows of scales, beginning with the first row. This extends to the vent where it covers two and two half rows, and still narrower to the end of the tail. A brown dorsal band commences in irregular spottings, a length of the head behind the same, and soon becomes solid,

covering three and two half scales to opposite the vent. It then contracts and continues to the end of the tail. A narrow black band extends from the gular region to the end of the tail across the ends of the gastrosteges, and is separated from the brown lateral band by a yellow stripe. Inferior surfaces unspotted, but shaded delicately with dusky. The centres of the scales of the first and second rows on the neck have a black central line, as have several scales on the throat and gular region. Some small black spots on the fourth, fifth and sixth superior labial scuta.

Total length, M., .668; length of tail, .153; of mouth to canthus, .016.

This very pretty species resembles the *Atomophis trilineatus* Burm., and the *Philodryas taeniatus* Peters. Besides the peculiarity in the double loreal plates, it differs from the former in the rounded muzzle. It is obliquely truncate in the species of Burmeister. According to Jan's figure the latter has the seventh superior labial a little longer than high, while in the *D. lativittatus* it is higher than long. The inferior lateral yellow stripe in the *A. trilineatus* is not black-bordered below. In the *Philodryas taeniatus* the preocular plate is scarcely visible from above; there are only seven superior labials, and the scales are said to be without pits.

56. PHILODRYAS NATTERERI Steindachner. Sitzungsber. d. K. K. Akad. Wissensch. Wien, 1870, p. 20; Pl. vii, figs. 1–2. Not rare.
57. PHILODRYAS VIRIDISSIMUS L.
58. PHILODRYAS OLFERSII Licht.

PROTEROGLYPHA.

59. ELAPS LEMNISCATUS L.

SOLENOGLYPHA.

60. BOTHROPS BRASILIENSIS Latr. Abundant.
61. BOTHROPS NEOVIDII Wagl. Three specimens.
62. CROTALUS TERRIFICUS Laurenti. *C. cascavella* Wagler, in Spix Serp. Brazil.

Several individuals, all alike and differing in color from the true *C. durissus* Linn. (*C. horridus* D. & B.). This is a brown snake with brown dorsal rhombs with narrow yellowish borders. The *C. durissus* is a yellow snake with brown dorsal rhombs which have yellow centres, the brown being little more than a border. The *C. terrifica* is figured by Seba, and by Wagler as above.

CONCLUSIONS.

The collection made by Mr. Smith is productive of a good many interesting results, especially to the knowledge of geographical distribution. Such are the great extension of the range of the anurous genus Prostherapis among Batrachia; of Anolis and Scartiscus among lizards; and of Rhynchonyx and Dirrhox among snakes. The rediscovery of a few species brought from the same region a half century ago by the Austrian, Johann Natterer, is of considerable interest. Such are the species *Paludicola nattereri* and *Philodryas nattereri* Steind. Other rare species only

seen in this collection for the second time, are the *Rhynchonyx ambiniger* Peters, *Rhadinæa occipitalis* Jan., *Leptognathus turgida* Cope, and *Scartiscus caducus* Cope. The number of species known and previously unknown, is as follows:

	New.	*Total.*
Batrachia	9	18
Lacertilia	0	15
Ophidia	3	29
	12	63

APPENDIX ON A LEPTOGNATHUS FROM SAN PAOLO.

LEPTOGNATHUS GARMANI, sp. nov. *L. catesbeyi* Cope, Proceeds. Amer. Philos. Soc., 1884, p. 193, not of Duméril and Bibron.

Renewed examination of the specimens on which the above determination was based, shows the determination to have been erroneous. A species from San Paolo has been named by Dr. Boulenger *L. ventrimaculatus*,* but the present snake, although resembling that species, does not belong to it.

Fifteen rows of scales, the median larger, but not maintaining its character as far as the occipital scuta. One pair of normal genеials, which are short, and are followed by two pairs which are arranged en chevron, the angle directed forwards. The anterior chevron leaves a triangular space between it and the normal genеial, to be filled by a triangular plate on each side. Seven superior labials, the seventh largest, the sixth next in size, and both longer than high. The fifth supports only the postocular, and the fourth the eye, so that the third only enters it by a corner on one side. Loreal a little longer than high. Oculars 0-2; nasals distinct; temporals 1-1-2. Internasals less than half prefrontals; the latter wider than long. Frontal wide as long, presenting angles both anteriorly and posteriorly, and about two-thirds as long as the large pariëtals.

Color light-brown, covered with numerous wide black cross-bands, which narrow towards the gastrosteges, and are sometimes divided on the middle line, one-half alternating with the other. The centres of the spaces of ground color are darker than the margins, and sometimes contain a black spot. Top of head blackish-brown, with a T-shaped mark in lighter brown extending from the occiput to the anterior superciliary region, and a brown cross-bar across the anterior part of the prefrontals. Inferior surfaces yellow, with two irregular series of small brown spots, one on each side of the middle line. The ends of the dorsal black spots involve the ends of the gastrosteges. Gastrosteges 158; anal entire; urosteges 59. Total length 478 mm.; of tail 105.

Sao Joao do Rio Negro; H. H. Smith. One specimen. The species is dedicated to the able naturalist of Cambridge, Mr. S. W. Garman.

* Ann. Magaz. Nat. Hist., 1885, p. 87.

A Geological Reconnaissance of Bland, Giles, Wythe and portions of Pulaski and Montgomery Counties of Virginia.

By John J. Stevenson, Professor of Geology in the University of the City of New York.

(*Read before the American Philosophical Society, March 18, 1887.*)

Introduction.
I. The Faults and Folds.
II. The Groups, with comparative notes.
III. The Area north from Walker mountain, Bland and Giles counties.
IV. The Area south from Walker mountain, Wythe, Pulaski and Montgomery counties.

INTRODUCTION.

The region described in this memoir, embracing Bland, Giles, Wythe and portions of Pulaski and Montgomery counties of Virginia, is the eastward continuation of the region described in the writer's previous memoirs* on the geology of Southwestern Virginia.

The examination of the area under consideration was purely a reconnaissance, and the notes in several localities must be regarded as little more than suggestions to the one who may make the detailed study on behalf of the United States Geological Survey.

The whole area is rugged. Even the Great valley, so wide in Washington and much of Smyth county, becomes broken in Wythe by the introduction of Potsdam ridges south from the railroad, while a new fault originating in Wythe county reproduces Big and Little Walker mountains in Cove and Max Meadows mountains north from the railroad. These break the valley in Pulaski county also, while the faults of Price mountain hold between them a Carboniferous area, which divides the valley in Montgomery county from New river almost to the line of Roanoke county. The whole region from the Tennessee line north-eastward to beyond the New river, as far as the writer has gone, is broken by successive pairs of Silurian and Devonian mountains separated by valleys of Lower Silurian limestone.

The Walker mountains, Big and Little, originating in Smyth county, are continuous to beyond the eastern border of Montgomery county. The latter ridge changes its name twice, becoming Cloyd's mountain as it approaches New river and Brush mountain beyond that stream; while the former retains its name to the river and thence becomes Gap mountain. Big Walker maintains its rugged features throughout and shows but two water-gaps, those made by Walker's creek and New river, which are separated by barely seven miles. Some wind-gaps exist, one of which, near

* These were read before this Society and are to be found in the Proceedings, Vol. xix, pp. 88 to 107, 219 to 262, 498 to 506; and Vol. xxii, pp. 114 to 161.

the west line of Wythe county, is thought to be available for a railroad line. Water-gaps through Little Walker are numerous, but with one exception they have been made by streams rising in the valley between the mountains or on the southerly slope of Big Walker. New river alone has made a continuous gap through both ridges. The ruggedness of Big Walker is due partly to the refractory nature of the Medina which forms its body, but more to the steep dip, which makes the mountain narrow and limits the effectiveness of erosion. The rocks of Little Walker are more easily affected by atmospheric agencies, and for the most part they have a much gentler dip.

The Clinch Mountain group, so conspicuous in the counties previously described, comes to an end in Giles county under the influence of two anticlinals and of extensive erosion on both sides of New river. The Medina outcrop, doubling over the anticlinals, forms Pearis and Sugar Camp mountains, while the Brushy mountain of Chemung and Vespertine disappears very near the line of Bland and Giles counties. But beyond New river the anticlinals diminish and the group reappears in the magnificent pile of Butte and Salt Pond mountains, the latter rising to fully 4500 feet above tide. These mountains extend eastward into Craig county, and are conspicuously visible from localities beyond Little Walker. Wolf Creek mountain, originating in Tazewell county as a loop of Clinch mountain, extends to Pearis mountain and thence is continuous with the others. The Garden mountains unite to form the anticlinal ridge of Round mountain, which gradually disappears in the broad space between Wolf creek and Brushy mountains, known as "the wilderness."

East River mountain, originating in Tazewell county, retains its name to New river, beyond which it becomes Peters mountain. Like the other Medina ridges, it is rugged and almost unbroken, the only water-gap for many miles being that of New river.

The mountains, Cove and Max Meadows, in Eastern Wythe and Western Pulaski, are short, being cut off at each end by a fault. The area occupied by them is comparatively rugged and imperfectly cleared, so that little examination was made of it. Lick mountain is about fifteen miles long and is wholly within Wythe county. It lies south from the railroad, is abrupt and almost uncleared. Draper's mountain, somewhat further east, is in both Wythe and Pulaski, and is even more rugged than Lick mountain, while its length is approximately the same. Price mountain, in Montgomery county, north from the railroad, is a short, by no means abrupt ridge, which extends from New river eastward for say eight miles, and attains its maximum at about five miles from that river.

The whole region, aside from the south-west corner of Bland county, is drained by the New river and its tributaries. That great stream rises on the Atlantic side of the Blue Ridge and flows across every fold of the great Appalachian chain until, as the Kanawha, it enters the Ohio at Point Pleasant. Its most important tributaries here are Reed and Cripple creeks in Wythe; Big and Little Reed Island, Peak and Back creeks in

Pulaski; Walker, Wolf and Sinking creeks in Giles. Most of these streams carry much water, and for a large part of the year afford power for mills; but the water-supply is not so regular as it was before so much clearing had been done, and floods are now too frequent. The New river, however, carries a large volume, and mills along its banks rarely suffer inconvenience.

Agriculturally the features of this region do not differ from those of the area already described, except that, as already indicated, the proportion of rich land is much less. The limestone areas are those indicated on the map by the number 6, all the other portions are sandstone or shale. Much of the sandstone region is abrupt or so rugged as to be worthless for ordinary farming purposes, but much of the shale land lies so well for cultivation that one feels more than regret because it is so thin. In seasons when the "rich" valleys yield twenty-five to thirty bushels of wheat, the "poor" valleys yield only from seven to ten bushels. The limestone areas are admirably adapted to grazing, as the grass is abundant and nutritious. The stock interests are extensive, and the cattle bring the highest price in Baltimore, Philadelphia and New York markets.

As the area described in this memoir does not reach to the West Virginia coal measures at the north, it offers a somewhat shorter list of mineral resources than do the areas previously examined. Clinton ore occurs on Big Walker, Round, Wolf creek and others of the Medina mountains, while brown hematite occurs on the southerly slope of those mountains and to some extent in the Lower Silurian limestones north from the Norfolk and Western railroad; but nothing is known positively respecting either the quantity or the quality of these ores. Brown hematite, zinc, lead and manganese ores occur abundantly in the southern part of Wythe, Pulaski and Montgomery counties, where the production of iron, zinc and lead has long been important. Little has been done toward developing the manganese. Coal occurs in the Vespertine along Brushy mountain in Bland county; Little Walker in Wythe, Pulaski and Montgomery; in the Peak hills of Wythe and Pulaski; and in Price mountain of Montgomery. It has been mined to a greater or less extent at several localities in Pulaski and Montgomery. Not a little good timber remains, but the charcoal burner at the south and the portable saw-mill at the north have done much destruction without bringing much profit to the owners.

The only outlet to market is by the Norfolk and Western railroad with its New River branch to the Pocahontas mines, seventy-six miles long, and the Cripple Creek branch from Pulaski to the rich mineral region of Southern Pulaski and Wythe counties. The topography renders construction of railroads difficult and costly, and the only easy line northward from the valley is occupied by the New River branch of the Norfolk and Western; but an available route is said to exist from Wytheville over Walker mountain near the Wythe and Tazewell pike. As the mountains are in pairs a promising water-gap in one usually leads to an impracticable crossing of the other, and the railroad engineer often finds his wits of

little service. Many routes have been surveyed in these and adjoining counties, and each new survey is an object of much interest. Some additional railroads would be an undoubted convenience, as, except the pike connecting the county towns of the Great valley, the roads are not macadamized, and the amount of labor expended on them clearly does not exceed the minimum required by law.

Those portions of this area which are underlaid by limestone are cleared and for the most part are under cultivation; but the other portions have comparatively few settlers and are traversed by roads usually not fit for light vehicles. As a rule the people are prosperous, utilizing the advantages which are available, while they waste little of their energies in discussing the value of the mineral wealth, which is of no immediate importance away from the Great valley. The villages in the valley are thrifty, have good church buildings and are well supplied with schools. The hamlets in Bland and Giles counties are very small and have little to support them.

Lists of Altitudes.

Mr. W. W. Coe, of Roanoke, Va., Chief Engineer of the Norfolk and Western railroad, has kindly given me the following list of elevations above tide:

On main line.

Crocketts	2327
Wytheville	2230
Max Meadows	2015
Pulaski	1904
Dublin	2058
New River	1768
Central	1778
Christiansburg	2007
New River Bridge	1760

On New River Branch.

Belspring or Churchwood	1766
Summit cut, 2½ miles from New River	1914
Staytide	1640
Ripplemeade	1607
Wenonah	1559

On the river.

Mouth of Walker's creek, about	1570
Mouth of Stony creek, about	1555
Thorn's ferry	1950

Mr. Oramel Barrett, Jr., of Abingdon, Washington Co., Va., has given

me the following list of elevations of points on Clinch and Holston rivers, on the line of the proposed Clinch River railroad.

Mouth of Thompson's creek	1518
Mouth of Weaver's creek	1502
Mouth of Dump creek	1480.5
Mouth of Bickley's Mill creek	1447
Mouth of Lick creek	1442
Mouth of Russell creek	1413
Mouth of Bull creek	1399
Mouth of Guest river	1373
Mouth of Little Stony creek	1332
Osborne's ford, about	1284
Railroad crossing at Dingus's	1255
Mouth of Big Stony creek	1248
Mouth of Cove creek	1226
Mouth of Stock creek	1203
Mouth of Copper creek	1196
Summit in "Big Cut," between Clinch and Holston	1579
Big Moccasin creek, below Estilville	1241
N. Fork Holston, at Holston Springs	1185
Same at mouth of Opossum creek	1176
Same at Virginia and Tennessee line	1175
Nash's ford, on Clinch, above five miles above mouth of Thompson's creek, about	1542

Some of the elevations given in this list by Mr. Barrett, differ from elevations of the same localities, as published in a former memoir. The discrepancy is due to the acceptance of a wrong determination of the locality where the work began.

I. THE FAULTS AND FOLDS

The Clinch River group of faults, including the New Garden, Stone Mountain and Abb's Valley, lie north from the area under consideration. They gradually diminish eastward in Mercer county, of West Virginia, and it is doubtful whether they pass in any case much beyond the line into Summers county, of the same State. Nothing further north than the edge of the House and Barn synclinal of the last paper was reached during this reconnaissance.

The geological structure of the southern part of this area is not unknown. Two sections were made by members of the Geological Corps, under W. B. Rogers, one passing through the eastern part of Wythe and Bland counties, the other through Roanoke and Craig counties, at a few miles beyond the eastern limit of the writer's study. Prof. Rogers, in his report of 1838, gave a summary account of the Vespertine coal areas. Prof. Lesley* published notes on the geology of Wythe, Pulaski

*Proc. Amer. Phil. Soc., Vol. ix, p. 30 et seq.

and Montgomery, and Prof. Fontaine* has given interesting details respecting the Vespertine coals. Mr. C. R. Boyd, of Wytheville, Va., has published a work, dealing with the economics of South-west Virginia, in which are given many geological details, with a map which topographically is a very notable improvement on its predecessors. The writer is under obligations to these publications which will be acknowledged in the proper connection.

The general type of structure is practically the same as that found in the areas already described, and it has been well represented by Lesley, who in his memoir on Tazewell county,† gives an ideal figure, which with his permission is reproduced as Fig. 1. The upthrow side, except in the case of cross-faults, is the south-east, and the Lower Carboniferous is found for greater or less distances in contact with the Lower Silurian limestones along most of the fractures. These faults are not simple, as is well shown in the Clinch group, but subordinate and cross-faults do not appear to arise directly from those of the principal system; and wherever a fault, either principal or subordinate, was followed out, it was found to originate or to terminate in an anticlinal. The faults are not parallel, they bear no relation whatever to the folds except such as is purely fortuitous, and their direction is wholly independent of the strike. A regular fault such as the Saltville exhibits this well, the upthrow group being in contact with different groups at different localities, owing to the influence of anticlinals on the downthrow side. Some interesting facts of this kind were given in the previous memoirs; others will be given in this, going to show independence of the faults and the folds and, as the writer intimated several years ago, suggesting very strongly a difference in age.

The structure is hardly so simple as that of the counties already described and the description cannot be given in so direct a manner as that of the other counties.

The Lick Mountain Anticlinal.

Lick mountain, at a little way southward from the railroad in Wythe county, is due to a strong double anticlinal, which diminishes rapidly eastward and is soon recognizable only as a gentle fold, followed by the Valley pike north-eastward for six or seven miles in Pulaski county. It was not traced beyond New river. How far westward it can be traced in Smyth county was not ascertained. It brings up the Potsdam in Wythe county, so as to form a very rugged mountain about fifteen miles long, but eastward it sinks so as to be crossed by the Knox shales before Reed creek has been reached; thence, as far as it was followed, no beds below the Knox shales are shown on the axis.‡ Some anticlinals in the Knox limestone were seen between the Lick mountain fold and the southern edges of Wythe and Pulaski counties, but they were not followed. One is crossed by the New river, very near the Wythe lead mine.

* Amer. Journ. of Science, Jan. and Feb., 1877.

† Proc. Amer. Phil. Soc., Vol. xii, p. 490.

‡ The easterly limit assigned to these shales on the map is conjectural.

The Fault of Draper Mountain.

At a mile and a half, or perhaps a little less, south from Reed creek on the road leading from Wytheville southward over Lick mountain, the Knox Limestones are much disturbed, being thrown into several close folds. On the Valley pike, probably a mile and a half from the first crossing of Reed creek, the upper limestones of the Knox are succeeded by red shales belonging at the base of the group; the fault rapidly develops and passes along the northerly side of Draper mountain, where it brings the lower beds of the Potsdam at the south into contact with the base of the Lower Carboniferous, and further eastward with the Chemung. It quickly diminishes eastward and soon is in the Knox limestone. An anticlinal is crossed by the Valley pike very near Newbern; it may represent the fault.

The structure of this fault is fairly well shown at several localities, but the conditions are complicated for much of the distance by two cross-faults coming the one from the north-west and the other, if the map be right, almost from the north. A section on and near the Valley pike in Wythe county is represented by Fig. 2, but the section crossing Draper mountain near the line between Wythe and Pulaski counties, as represented in Fig. 3, shows a very different condition, for here the Max Meadows cross-fault is seen. The Knox limestones certainly describe an anticlinal near the fault, but whether or not they dip away at the fault could not be ascertained. The Potsdam forms the heart of this very rugged mountain and is dipping south-eastwardly at from thirty-five to nearly sixty degrees. Further east, where the road crosses Draper mountain to Pulaski, the structure is as given in Fig. 4. The structure is distinct along this road for the Devonian shales are turned up at the fault so as to be actually conformable in dip with the lower shales of the Potsdam. The exposures along this road in descending the mountain are practically continuous, yet it will be found difficult to determine accurately the place of the fault, so closely do the shales resemble each other and so nearly exact is the conformability of dip. In all probability, the Vespertine is brought into contact with the lower beds of the Potsdam at a short distance west from the road, so that this is the most formidable fault yet noticed. The Pulaski fault cuts off the Devonian and Carboniferous, and the Lower Silurian beds are on both sides of the fault beyond Peak creek.

The Area between the Norfolk and Western Railroad and the Walker Mountain Fault.

The village of Wytheville, county seat of Wythe, is built on a ridge marking the course of the Wytheville synclinal, which, beginning certainly more than six miles westward from Wytheville, extends east-northeast to where it is cut off by the Max Meadows fault north from Max Meadows station. A well-marked anticlinal bounds it on the southerly side, which is crossed by the Valley pike near Kent's mills, three miles

and a half from Wytheville, and it may be the same with that seen near Max Meadows on the railroad. It is crossed very near Reed creek on the Lick Mountain road. The dips in this portion are interesting. Within the synclinal ridge, composed of Knox Limestones, the dip is fifty to sixty degrees on both sides. The anticlinal brings up the Knox shales, which are shown on the railroad just west from Kent's mills. The south-easterly dip looking toward the Draper Mountain fault is at first very abrupt, being almost vertical for some distance along the pike, but it becomes gentler until the higher limestones have a dip of not more than twenty degrees.

The Max Meadows fault has its origin evidently in an anticlinal, which is crossed by the Wythe and Tazewell pike at say two miles and a half from the Wytheville borough line; it is crossed by Cove creek very near its forks and by the Norfolk and Western railroad at not far from three miles and a half beyond Max Meadows station. At a little distance further it must unite with the Draper Mountain fault. It cuts off the Wytheville anticlinal and synclinal at the east, while on the other side it cuts off a broad synclinal and an anticlinal which are well shown in eastern Wythe and western Pulaski and may be continuous with the Wytheville folds; but of this, one may not speak positively. The fault becomes greater as it extends south-eastwardly at an angle with the strike, so bringing Hudson, Medina, Clinton, Hamilton, Chemung and Vespertine successively into contact with the Knox limestones and shales on the opposite side.

The Pulaski fault, like the last, is a cross-fault and is the easterly boundary of the area of newer rocks held between the Walker Mountain, Max Meadows, Draper Mountain and Pulaski faults. The details of this fault were not worked out, but if the map employed be accurate, the direction from the Walker Mountain fault is almost south-south-east to Pulaski, where the course is changed to east-south-east. Evidently the line is south from Peak creek for more than two miles below Pulaski. Knox limestones are shown throughout on the easterly side of the fault, but on the opposite side are Devonian and Carboniferous rocks as far as followed. The region embraced within these faults was not worked out in detail, as much of it is not cleared; but it is evident that Cove mountain and its Devonian companion are monoclinals and there is every reason to suppose from the exposures along the railroad that an anticlinal exists in the Peak hills, the low ridge directly north from Pulaski. The limits assigned to the several groups within this area are largely conjectural.

The structure of Pulaski county east from the Pulaski fault is not shown satisfactorily along the roads, but cuts along the New River branch of the Norfolk and Western railroad make the structure clear. The Knox limestones are badly twisted for two miles and a half from New River station, but afterwards for nearly a mile they dip quite regularly to the north-west. The dip is reversed at three and a half miles and thence for a mile the pre-

vailing dip is south-east, though there are some reversals. The dip becomes very flexuous at four miles and a half, and the same beds remain in sight thence until near Belspring station, where all exposures cease. The structure may be regarded as representing two anticlinals with irregular crests, separated by a well-defined synclinal, whose axis is somewhat more than two miles south from Belspring station. The northerly anticlinal is cut off by the Walker Mountain fault.

The faults of Price's mountain east from New river in Montgomery county hold between them a fragment of an anticlinal, the Price Mountain area of Vespertine coals. Between the Walker Mountain fault at the north and the northerly fault of Price's mountain, the Knox limestones describe a synclinal, though the few and unfortunately somewhat indefinite exposures show that it is complicated. The lower beds of the Knox limestone are brought into contact with Umbral red shales, but whether they are dipping to or from the fault could not be ascertained. The limestone on the northerly side dips northwardly at fifteen to thirty degrees, while the Lower Carboniferous rocks beyond the fault are dipping in the same direction at thirty to fifty-five degrees, the rate increasing toward the summit of the Price's Mountain anticlinal. The dip is gentler on the southerly side of the axis, rarely exceeding twenty degrees. The conditions at the southerly fault were not clear at the only point where it was crossed, further than that the Umbral shales and the Knox limestones are in contact. The eastward extent of these faults was not ascertained. They do not appear to cross New river at the west.

The Walker Mountain Fault.

This fault, following the southerly foot of Little Walker mountain, enters Wythe from Smyth county and, at the county line, brings Knox limestone into contact with the Vespertine sandstones. The line of fault is crossed by Stony fork of Reed creek at somewhat more than six miles from Wytheville, its place being shown there by a narrow valley passing in front of the M. E. Church. The church is on Umbral shales, while Knox limestones crop out on the opposite side of the bottom. The conditions are the same in Crockett's cove, but in Pulaski county for several miles they are very different. There the Lower Carboniferous beds on the northerly side must be brought into contact successively with Lower and Upper Silurian, Devonian, and possibly with Vespertine near the Pulaski fault; beyond that fault, Knox beds occur again. The fault-line passes but a little way south from the Altoona mine; is crossed by the Dublin and Pearisburg pike at half a mile, possibly a little more, north from Back creek; by New river just below the mouth of Back creek; and by the Newport and Christiansburg road at only a little way south from Tom's creek: in each case bringing the red Umbral shales into contact with the lower limestones of the Knox group.

Generally speaking, the structure in the vicinity of this fault is simple, and notwithstanding the enormous vertical extent of the fracture, the

crushing and distortion are very much less than that observed near the New Garden fault in Tazewell county, the Hunter valley fault in Russell, or even the Max Meadows fault on the railroad. Where crossed by the Wythe and Tazewell pike it shows dips of thirty to forty degrees in the Lower Carboniferous, and forty to fifty-five degrees in the Knox limestones at about equal distances from the line of faulting; on the Dublin and Pearisburg road, the dip is comparatively gentle and the succession of Lower Silurian on top of Lower Carboniferous appears to be wholly conformable; a similar condition exists on New river, where the dips in the Umbral shale near the fault are only ten to fifteen degrees, while in the Vespertine further from the line the dip rises to fifty-five degrees. Here, however, the rocks on the southerly side are disturbed, and the beds are wrinkled for a mile or more. Near Tom's creek the greater disturbance is on the northerly side, where the Lower Carboniferous beds are almost vertical, though dipping toward the fault, while the Knox limestones are dipping much less sharply in the same general direction.

The structure between the Walker Mountain and Saltville faults is much less complicated than that of the next block southward. The Vespertine Coal group is exposed continuously on the northerly side of the former fault from eastern Smyth to beyond the centre of Montgomery county, and the course of the fault is so little off the strike of the beds that the thickness of the overlying Umbral shales shows very little change from Wythe county eastward. Big Walker mountain is a Medina ridge separated by a Clinton and Hamilton valley from Little Walker mountain, an Upper Devonian ridge with Lower Carboniferous sandstones and shales on its southerly slope. The dip throughout, or nearly so, is south of south-east at from ten to sixty degrees. Petty wrinkles occur in the shales, but the only material interruption of the dip on Big Walker is near the Tazewell pike, where at barely five or six miles from the Smyth county line an anticlinal evidently has its origin. This rapidly increases eastward and soon causes a considerable southward deflection in the Medina outcrop or crest of Big Walker mountain. The axis must be cut several times by Walker's creek, which flows on Knox limestone along the northerly foot of the mountain; and the fold shows no material decrease until beyond the line of Bland county; but thence to New River gap, the Medina of Walker mountain gradually approaches the Saltville fault. The interval between that fault and the Medina opposite Seddon is fully three miles, but at New River gap it is barely one mile.

The dips on the northerly side of Big Walker are comparatively gentle except for a few miles on each side of the New River gap; and it is worthy of notice in this connection that the dips throughout Big and Little Walker along the New river are much more abrupt than at any other localities. Possibly the approach of the Medina outcrop to the Saltville fault may be due as much to a thrust as to diminished strength of the Walker Creek anticlinal.

The Saltville Fault.

This interesting fault, originating in Tennessee, enters Bland county just north from the Saltville and Sharon Springs road; passes at only a few rods north from that road at Sharon Springs; less than one-third of a mile north from the cross-roads at Seddon; lies north from the road for six miles beyond Seddon; thence for two miles is south, but is again crossed so that it is only a few rods north from the forks of the road at Poplar hill, in Giles county; it is crossed by New river in Buckeye mountain, very near Scott's ferry; and by the Salt Pond and Newport road in a wind-gap through Buckeye mountain at half a mile north from Newport. The dips of the southerly side are regularly south-south-eastward, and not very abrupt, rarely exceeding twenty five degrees; those on the northerly side are equally regular except near Newport, where the Trenton shales are faulted against the Knox limestone and the former are badly twisted.

The Knox limestones are shown on the southerly side of the fault, and notwithstanding the great variations of horizons on the northerly side, there is comparatively little change on the southerly side—even less than might be expected from the influence of the Walker Creek anticlinal. The variations on the northerly side possess much interest, but being due to the Clinch Mountain group of folds cannot be described until after those folds have been discussed.

The Clinch Mountain Group of Folds.

Where first seen, in Scott county, Clinch and its associated Brushy mountain make up a broad monoclinal, showing a section from Medina on the crest of Clinch mountain to the highest Umbral rocks at the Saltville fault. The width of Upper Silurian and Devonian is barely three miles. In Smyth and Tazewell, however, a fold, the Burk's Garden anticlinal, arose at the foot of Clinch mountain, widening the area of Silurian and Devonian, and narrowing that of the Lower Carboniferous until at the line of Wythe county only the Vespertine remains. Similarly, gentle folds in Russell and Tazewell interrupt the dip at the north and the Medina outcrop is carried further in that direction, so that Rich mountain, whose crest is merely the continuation of Clinch mountain around a petty anticlinal, lies nearly a mile north from the previous line of Clinch. So the monoclinal of Scott county is interrupted by a great fold with a broad synclinal at the north as it enters Bland county. The structure becomes more complicated within Bland and Giles, but gives promise of returning simplicity as the group passes into Craig county beyond the limits of the writer's examination.

The Burk's Garden fold, which attains its greatest maximum in the cove of that name, quickly flattens, so that at the easterly end of the cove, the Medina outcrops of Garden mountain unite and that sandstone crosses the fold in Round mountain. The decrease is so rapid that within five miles

the Hamilton crosses the anticlinal, which at four miles further eastward seems to have disappeared.

The Pearisburg synclinal, between the Cove and Elk Garden anticlinals in central Tazewell county, lies between the Elk Garden and Burk's Garden anticlinals in eastern Tazewell, owing to the disappearance of the Cove fold. Wolf creek, rising in Burk's Garden, flows for more than fifteen miles in this synclinal within Bland county, so that Rich mountain of Tazewell, continuous with Clinch mountain further west, becomes Wolf Creek mountain of Bland county. The disappearance of the Burk's Garden fold and the rapid growth of the Kimberling anticlinal keep this trough distinct to beyond the eastern limit of Giles county. Brushy mountain, the Devonian ridge with Vespertine foothills, continues to about the eastern border of Bland, where under the increasing influence of the new anticlinals the mountain gradually disappears.

The Kimberling anticlinal was first observed on the Seddon and Mercer county road, where, though narrow, it is distinct at not far south from the summit of Brushy mountain. To the influence of this anticlinal, most probably, is due the widening of the Vespertine area further west as shown on the road crossing Brushy mountain to Hunting Camp creek. The "Wilderness" road, leading from Kimberling creek to Rocky gap, crosses the anticlinal at say a mile* from the junction of Kimberling with No-Business creek. This fold, rapidly increasing in height, causes the broad space of Devonian shales, known as the "Wilderness," which extends from Brushy mountain northward almost to the foot of Wolf Creek mountain. It soon brings up the lower rocks and the Medina in crossing it forms a long V, with the opening toward New river. The northern arm, known as Pearis mountain, reaching north-north-eastward into the Pearisburg synclinal, terminates in a peak—the Angels' Rest—near Pearisburg, where it bends on itself and becomes continuous with Wolf Creek mountain. The southerly arm is Sugar Run mountain, pointing out in the synclinal between Kimberling and a new anticlinal, the Sinking Creek, which first appears along the Saltville fault at a little way east from the Bland county line. The Kimberling anticlinal attains its maximum elevation between Walker creek and the Dublin and Pearisburg road, whence it diminishes rapidly toward the north-east. Erosion has been effective on both sides of New river, so that for several miles Lower Silurian limestones are the immediately underlying rocks.

But the comparatively rapid flattening of the Kimberling anticlinal permits the Medina to appear in the Pearisburg synclinal with double outcrop as Butte mountain at, say four miles eastward from New river. The course of the fold and its loss of elevation are shown by the deep re-entrant angle between Butte and Salt Pond mountains. The latter is the double outcrop of Medina in the synclinal between the Kimberling and

*Many of the distances given in this memoir were determined by "dead reckoning," there being no other means of making determination in the thinly settled portions. They may be either too large or too small.

Sinking Creek anticlinals, but it does not extend so far westward as Butte mountain, for the Sinking Creek anticlinal attains its maximum at a little way eastward from New river and Medina does not cross it until very near the easterly line of Giles county. This fold is crossed by the Salt Pond and Newport road at barely two-thirds of a mile north from Sinking creek.

For the most part the dips in the synclinals are not very abrupt; but the "Wilderness" road in crossing the Pearisburg synclinal shows Chemung with fifty degrees northerly, and almost vertical southerly dip. Northward the dip diminishes, for in Rocky gap through Wolf Creek mountain the Medina shows only twenty-six degrees. Further eastward in this trough, at the end of Butte mountain, the calcareous shales of the Trenton have been thrown into numerous and very narrow flexures. A similar condition exists in the Salt Pond synclinal on the Salt Pond and Newport road where some of the petty folds show distinct faults.

The effects produced by the Saltville fault in cutting across the southerly slope of the anticlinals are shown by the map. As the Burk's Garden anticlinal diminishes, the width of the Lower Carboniferous area increases, so that at Sharon Springs the Umbral red shales appear; but as the Kimberling anticlinal increases, the width diminishes and the whole of the Lower Carboniferous is finally lost in the fault near the Giles county line. Devonian, Upper Silurian and the upper beds of the Lower Silurian are cut off quickly at a little way further east under the added influence of the Sinking Creek anticlinal and of erosion by Walker's creek and New river, so that for several miles east and west from Poplar hill, the fault is in Knox limestone. Thence north-eastwardly to the county line, Medina is found on the northerly side of the fault, except at New River gap and for a few miles on each side of Sinking Creek gap, where erosion has cut away both Medina and Hudson.

Knox limestone is continuous on the southerly side of the Saltville fault from the Smyth county line to the end of Giles county. It is in contact with Lower Carboniferous in Bland, with Chemung, Hamilton, Clinton, Medina, Hudson, Trenton and Knox within eight miles eastward from the line of Giles county; and with Medina, Hudson or Trenton, according to extent of erosion, thence to the end of the region examined. The relations are shown in Figures 5, 6 and 7, which are merely diagrams, not actual measured sections.

The Elk Garden Anticlinal and Wolf Creek Faults.

The Elk Garden anticlinal of Russell and Tazewell counties gives rise to the Copper Creek fault in western Russell. The anticlinal continues in eastern Tazewell between Wolf Creek and East River mountains to within less than four miles of the Bland county line; but at some place between that and two miles west from Rocky gap in Bland county it gives rise to a double fault, the Wenonah, which was followed to within eight miles of the Craig county line. Another fault, that of Buckhorn mountain, origi-

nates nearly opposite Rocky gap or Wolf Creek gap, through Wolf Creek mountain, where it cannot be more than a few rods distant from the Wenonah. This was followed to somewhat less than twelve miles east from New river. But both faults must extend several miles further than the writer's examinations went.

The Wenonah fault, whose course is shown by the Valley ridge of Wolf Creek valley, is crossed by Wolf creek at a little way below Rocky gap, but not again except, perhaps, above the "round bottom;" it is crossed by New river at Wenonah; is touched by Big Stony creek at one mile from the river, and its peculiarities are well shown at three miles from the river on the road leading from Big to Little Stony creek. Where first seen, this fault is in Knox limestone and holds a wall of Medina and Clinton in its jaws. As one comes from the "Wilderness" through Rocky gap of Wolf Creek mountain, he finds the complete succession from Medina to Knox limestone; but within a mile below the gap he reaches the fault. There the creek breaks through the Valley ridge, in which Medina is shown with dip of eighty degrees, while on the lower, as on the upper side of the ridge, Knox limestone is shown against the Medina. The wall of Medina is wanting at Wenonah, where the fault shows Knox on both sides. The Valley ridge shows two sets of faults instead of one at three miles east from New river, where two lines of Medina are present.

The Buckhorn fault, whose course is shown by Buckhorn mountain and Little mountain, a ridge following the southerly foot of East River and Peter's mountain, is crossed by the Wolf Creek road after passing through the Valley ridge, nearly one mile below the Rocky gap. It is recrossed on the hill overlooking Mr. Carpenter's house at say two miles and a half from the gap. Thence, neither road nor creek touches the fault, though they approach it closely at the Giles county line. It brings Medina or Clinton into contact with Knox limestone.

The lines of faulting are not exposed. A reversed dip is shown on the north side of the Wenonah fault at one locality on Big Stony creek; and the Medina shows a flexure on the southerly side in the Wolf Creek gap through the Valley ridge; so that there is evidence of dragging at both localities. The dips in the intervals between these faults rarely exceed forty degrees and ordinarily are between twenty and twenty-five degrees. The interval is but a few rods wide at the gap through the Valley ridge, but beyond the New river it is nearly two miles. The faults disappear at no great distance beyond the limits of the writer's examination, for in the Rogers section, an anticlinal is shown along the foot of East River mountain in Craig county.

The House and Barn Synclinal.

Nothing was ascertained respecting the structure of this trough, which seems to be less and less complicated eastward. East River mountain is a monoclinal ridge with Medina as the backbone, and there must be a

synclinal between it and the similar ridge of Buckhorn mountain. The valley between these ridges is reported to show only shale.

The Clinch Faults.

The Clinch River system of faults continue from Tazewell county into Mercer county of West Virginia, which lies beyond the area examined for this memoir. The New Garden fault passes at a little way north from East River mountain and continues eastwardly beyond the eastern limit of Mercer county, as appears from the Rogers' section; but it is greatly diminished in eastern Mercer, for there it is in Devonian rocks, whereas in Tazewell it brings Quinnimont into contact with Knox limestone. The Stony Ridge and Abb's Valley faults certainly disappear before the eastern line of Mercer county is reached, unless their course has been greatly changed, for the writer found no trace of them in Summers county, of West Virginia, where they should be found.

The extreme vertical extent of the several faults is approximately as follows:

Draper mountain	12,500 feet.
Max Meadows	9,800 "
Pulaski	9,600 "
Price mountain	10,000 "
Walker mountain	10,000 "
Saltville	10,000 "
Wolf creek	2,000 "

II. THE GROUPS, WITH COMPARATIVE NOTES.

The section is a long one, reaching from the Umbral of the Lower Carboniferous to the lower beds of the Potsdam. No detailed measurements were attempted and in most cases no effort was made to estimate thicknesses. Only the more general features are summarized here, as most of the details given in previous memoirs are equally applicable to this area.

The Carboniferous.

The Coal Measures are not reached but the Lower Carboniferous is represented by the Umbral and the Vespertine. These groups are shown in Bland county along the southerly slope of Brushy mountain; in Wythe, Pulaski and Montgomery counties, they form the foothill of Little Walker mountain; they are present in Wythe and Pulaski counties in the area between the Max Meadows and Pulaski faults; and in Montgomery, on Price mountain.

The Umbral.—Prof. Fontaine makes the thickness of the upper portion, the Umbral red shales and shaly sandstones, to be 1090 feet in Brush and Price mountains of Montgomery county, and the writer finds 996 feet in the New River gap through Brush or Little Walker mountain. In the Memoir on Lee county, &c., the writer regarded these Montgomery county shales as Vespertine, but he now feels that that identification is

erroneous and that the shales belong to the Umbral or Greenbrier series. These shales are well shown on the various roads crossing Brushy mountain in Bland and especially well along the various roads crossing Little Walker, in Pulaski and Montgomery counties. They occasionally contain a thin bed of coal, which was seen on Brushy mountain, in Bland, and on the Norfolk and Western railway near Clark's summit, in Pulaski county; but the bed is of no importance. The rocks are reddish shales, mostly sandy, occasionally compacted into earthy sandstones; but in nearly all cases the bedding is irregular. So far as observed, these beds are not fossiliferous.

A silicious limestone, too impure to be used in making lime, occurs under these shales. It is said to be seven or eight feet thick on Stony Fork of Reed creek, in Wythe county: it is rather less on the railroad in Clark's summit cut four miles and a half east from Max Meadows; and is a little thicker on Brushy mountain, in Bland county. In many ways this is exceedingly suggestive of the silicious limestone which occurs at the summit of the Vespertine in Pennsylvania and it may be the representative of that rock. This limestone the writer takes to be in all probability the separating bed between the Umbral and the underlying Vespertine, but with greater affinity with the latter. Unfortunately, the only locality where measurements can be made without great expenditure of time is along New river, but there the limestone was not recognized and an arbitrary line had to be assumed for separation of the two groups.

The variations in the Umbral within South-western Virginia are not without interest. The section obtained in Lee county showed

1. Shales and sandstone with thin limestone.....705′
2. Limestone and calcareous shales .....150′
3. Cherty limestone..... .....200′

In Brushy mountain of Washington county on north side of the Saltville fault, the upper division retains its thickness while the lower divisions increase vastly, the measurements being,

No. 1..... 800 feet.
No. 2.....1470 "
No. 3..... 605 "

But in western Smyth county, where the group is crossed by the road leading to Saltville through Brushy mountain, there is manifestly a serious decrease in thickness of the limestones, while the shales appear to have decreased very slightly. Within Bland county, in the same mountain, the red shales are found thick, but the limestone has disappeared. This is simply the condition which one should expect to find here, when it is remembered that on the north-westerly side of the Great Valley in Pennsylvania and Maryland, limestone is found almost wholly absent from the isolated patches of Umbral: similarly, with the disappearance of the calcareous matter, the fossils disappear. Prof. Fontaine came to the same conclusion with respect to the relations of these shales after com-

paring them with the section obtained near Lewisburg, in Greenbrier county, of West Virginia.

The Vespertine.—This great period is represented by sandstones and shales with coal beds, having in all an extreme thickness of not far from seven hundred feet. The bottom of the group is taken to be a grayish sandstone, sometimes slightly conglomerate, often with impressions of *Spirophyton*, and about thirty feet thick. It is a characteristic rock resting directly on sandy beds which mark the transition to Chemung and in which the dividing line cannot be drawn very closely. On this sandstone rests the succession of shales and sandstones, the latter varying from gray to blue or red, from compact to shaly, from good building stone to miserable rubbish. The general succession is fairly well shown in many of the smaller gaps through Brushy mountain of Smyth and Bland, as well as in the similar gaps through Little Walker in Wythe, Pulaski and Montgomery; a more accessible section is along the Norfolk and Western railroad for seven or eight miles west from Pulaski.

The change in this group is as marked as that in the Umbral. The section in Lee county shows

Reddish silicious beds, some shale.....150 feet.

Some part of which must represent the Vespertine. No coal was seen here. In the North Holston section near Mendota, in Washington county, the Vespertine can only be in the concealed space of eighty feet at the bottom. But the sandy beds increase toward the north-east so that before the line of Smyth county has been reached a coal has been mined in the river bed, while the shales and sandstones form a notable foothill to Brushy mountain. At the Laurel gap, in Smyth county, the estimated thickness is about 500 feet, while in the same ridge within Bland county, the thickness appears to be approximately the same. But followed northwestward into Tazewell county, this division is found insignificant where shown among the Clinch faults, being thinner on Indian creek than in Pennington's gap, in Lee county. Along the foot of Brushy and Little Walker mountains, one finds the Vespertine very much as in South-central Pennsylvania, a mass of shales, sandstones and irregular coal beds, capped by a silicious limestone.

The feature of especial interest is the great development of Vespertine coal beds within Wythe, Pulaski and Montgomery counties. These have been worked, especially in Montgomery county, for many years, and a summary account of them was given by Prof. W. B. Rogers, in his report for 1838. Prof. J. P. Lesley gave an excellent statement respecting the beds and workings as they existed in 1860; while Prof. Fontaine has described in detail the beds of Brush and Price mountains, in Montgomery county.

According to Capt. Boyd, thirteen beds or streaks of coal occur in a vertical space of less than 400 feet within the gap made through Little Walker mountain by Stony Fork of Reed creek. The first five of these beds are embraced within a column of 100 to 120 feet, No. 1 resting on the

sandstone, known as "Quarry rock," which the writer has assumed as the base of the Vespertine. The first three beds alone possess any economic interest, as no others are mined anywhere within this region.

The lowest bed is usually very thin, but on Cloyd's mountain in Pulaski, and on Brush mountain in Montgomery, it becomes of workable thickness, two and a half to three feet. The second bed has been opened near the Wythe and Tazewell pike in Wythe county; at the Altoona mine in Pulaski; at several places along Tom's creek in Montgomery, all in the foothill of Little Walker or Cloyd's or Brush mountain, as the ridge is termed in different portions of its extent. Apparently the same bed has been mined near Sharon Springs, in Bland county; and on Price's mountain, in Montgomery. It varies from nearly four feet of nearly solid coal in Wythe to twenty-two feet of shale and coal in Pulaski, and nine or ten feet of coal and shale in Montgomery. But these are extreme measurements and the bed exhibits great and sudden variations in thickness, owing to the immense pressure which the yielding material has suffered. A similar condition exists in Bland county; but the variations in Price's mountain are comparatively small. The third bed was mined systematically only at the Altoona mine in Pulaski, though it was opened in Wythe county, near the Wythe and Tazewell pike. Its thickness at these localities is said to be between three and four feet. It is not worked now.

The physical structure of the coal shows great variations, which cannot be accounted for always by supposing different degrees of pressure. The coal from the second bed appears everywhere to have undergone much greater change than either the first or the third. In Wythe county at the Boyd mine, in Pulaski; at the Altoona mine and on the Dublin and Pearisburg road; and in Montgomery county, on Tom's creek; as well as in Bland county, near Sharon Springs, the coal from the second bed appears to have been crushed into fragments, which were pressed and rubbed until they were reduced to laminæ, so loosely packed in many places as to be easily separable by the fingers. But the coal of the first or third bed may be found on the same hillside, hard enough to bear transportation, though it shows with sufficient distinctness that it too has been subjected to severe crushing and rubbing. It has been broken into fragments, which have been rubbed together until thoroughly glazed. But the rubbing did not reduce the fragments to laminæ.

This variation may be due to difference in chemical composition or to the fact that the thinner beds are not broken by shale partings. It is of interest, however, to note that notwithstanding all this crushing and rubbing, the penetration of coal layers by shale layers in the second bed is no greater than that often seen in coal beds within the very little disturbed Coal Measures area of South-western Pennsylvania and the adjacent parts of West Virginia. The crush of strata in Price's mountain has been comparatively slight, despite the faulting, though there also, it is sufficiently clear that the greater part of the crushing was endured by the coal, as being the more yielding substance.

Analyses of coals from several of the pits have been made by Mr. A. S. McCreath, the accomplished chemist of the Second Geological Survey of Pennsylvania. The results taken from his memoir on the Resources of Virginia, are as follows:

1. Guggenheim bank, Brush mountain, near head of Tom's creek.
2. Smith bank, also on Brush mountain, one mile further east.
3. Blacksburg M. & M. Co., also on Brush mountain.
4. William Perfator, also on Brush mountain.
5. William Meyers, Price mountain.

All of these are from Montgomery county:

6. Altoona mines, Pulaski county.
7. Stony Fork, of Reed creek, Wythe county, 2d bed.
8. Same locality, 4th bed.

	1	2	3	4	5	6	7	8
Water	1.228	0.816	0.615	0.725	1.080	0.236	0.466	0.620
Volatile matter	11.652	11.324	12.870	12.215	9.675	9.459	16.264	17.853
Fixed carbon	73.012	75.618	70.924	72.737	74.013	49.353	55.615	59.427
Sulphur	0.548	0.697	0.481	0.333	0.682	1.122	0.995	1.575
Ash	13.560	11.545	15.110	13.990	14.550	39.830	26.660	20.525

The coal from several of the mines is in good repute. Much of that from Tyler's mine near New river is used as grate fuel in villages along the railroad west from New river. The Tom's Creek mines are worked and the coal is carried in wagons nine or ten miles to Bang station, on the railroad, whence, with the Price Mountain coal, it is distributed to villages in the vicinity. In spite of the great percentage of ash and the much higher cost per ton, the Tyler and Price Mountain coals are preferred to Pocahontas coal for grates, as they are practically free-burning, having very slight tendency to coke. The Altoona coal is used at the salt-works in Smyth county, and at the Bertha zinc-works in Pulaski.

A comparison of the fuel ratios is interesting. Arranged in order from north-east to south-west along the foot of Little Walker mountain we have

No. 2	15	85
No. 1	16	84
No. 3	18	82
No. 4	16	84
No. 6	19	81
No. 7	29	71
No. 8	30	70

An analysis of the Tom's Creek coal is given in Prof. Rogers' report for 1836, p. 17, which shows the ratio of

Volatile	16
Fixed	84

or the same as No. 2, of Mr. McCreath's analyses of Tom's Creek coals. These analyses show that the proportion of the volatile combustible matter decreases north-eastward, so that one is prepared to find not a semi-bituminous coal such as these, but a true anthracite in Narrowback mountain at the Dora mines further north-north-east, near Harrisonburg.

The material for comparison of the areas lying further south-east, in the Valley, does not exist. No analyses of coals in the area between Max Meadows and Pulaski have been made, so far as the writer knows; only one analysis of the Price Mountain coals by McCreath, and one of the Catawba coal in Botetourt county by Rogers, have fallen under the writer's notice; these show:

Price mountain	13	87
Catawba.....	21	79

a very notable difference. Whether or not the specimens were taken from different parts of the same bed or from different beds cannot be ascertained.

The Vespertine coal beds attain their chief importance within the counties of Wythe, Pulaski, Montgomery, Roanoke and Botetourt, a distance along Little Walker mountain of barely 105 miles. But isolated patches of slight extent preserved in synclinals within Augusta and Rockingham counties, show that the field with beds of workable thickness extended to certainly 100 miles further north-north-east, thus giving a length directly measured of nearly 200 miles. Exposures in Wythe, Pulaski and Roanoke show that the Vespertine beds reached far into the area now known as the "Great Valley," fragmentary patches still remaining at a distance of barely twelve miles from the Archæan, while exposures in Bland and Rockingham show that the productive coal area in Virginia extended to some distance beyond the line of the Saltville fault. Certainly it was 200 miles long by fifteen miles in Virginia; and the width may have been twelve miles greater toward the south-east, reaching to the Archæan. The whole area may be estimated at beyond 5000 square miles, of which only insignificant strips and patches have escaped erosion, amounting in all to not more than 130 square miles. How much further north-eastward this area extended cannot be determined, for in Pennsylvania and Maryland the numerous folds with the disappearance of the faults have thrown the most easterly outcrop of Vespertine, to a distance from the Archæan greater than that of the Abb's Valley fault from the Archæan in Virginia. No workable coal beds occur in Pennsylvania and Maryland within the Vespertine, but what existed in that portion of the Vespertine which has been removed by erosion, we may conjecture from the conditions occurring in Virginia within the same space.

Within Virginia the coal beds diminish quickly in importance in all directions from the area already defined. South-westward, the coal-bearing division of the Vespertine diminishes and the last trace of it occurs on the North fork of Holston, near Mendota, in Washington county, where coal is said to be found in the river-bottom at low water. North-westward

the coals diminish. In Lee, Wise, Russell and Tazewell counties, of Virginia, this lower division is either insignificant or wanting—but further north-west, in Greenbrier county, of West Virginia, Prof. Fontaine* found the sandstone division with strings and beds of coal, which, however, are interesting more because of their existence than because of any economical importance. The total thickness of the whole series there is about 290 feet.

No Vespertine is found in or immediately adjoining the Great valley, beyond Augusta county, of Virginia; but the petty areas preserved on the crests of synclinal ridges are among what Prof. W. B. Rogers termed the Allegheny mountains, in Hardy, Hampshire and Morgan counties, of West Virginia. There the coals are usually very thin, as they are also under the great anticlinals of Randolph and Tucker counties, of West Virginia, Allegheny county, of Maryland, Bedford, Huntingdon, and the counties further north in Pennsylvania. The coal is present in all of these, but not in such shape as to deserve more than passing notice; the thickness seldom exceeds a few inches and the large percentage of ash leads most persons to regard the coal as anthracite. Along the lines mentioned, the sandstones show a decided thickening, becoming 1100 feet or more in Bedford county, of Pennsylvania; but the thinning is very marked in a north-westward direction, as the whole thickness in Fayette county, of Pennsylvania, is barely 400 feet. There, the last westward exposure on the easterly side of the Appalachian region, it appears to contain no coal.

The Devonian.

The Devonian is represented by Chemung and Hamilton only, the Catskill and Carboniferous being absent. In Bland and Giles counties Devonian rocks occur in the "Wilderness" area of Kimberling creek, and they make up the great part of Brushy mountain, in the former county; they underlie the "Poor valley" of Walker mountain, and make the mass of Little Walker and Max Meadows mountains, while a narrow strip lies along the north side of the Draper Mountain fault in Pulaski county. Except in the "Wilderness," where the Oriskany was recognized, no line could be drawn between Devonian and Upper Silurian, the shales of the one passing interceptibly into the shale of the other.

Chemung.—The Chemung, as seen on the North Holston near Mendota, is 350 feet thick, but it is wholly absent from Stony mountain in Lee county. Eastward, or rather north-eastward in Brushy mountain, the thickness increases rapidly, so that north from Saltville, in Smyth county, it is certainly twice as great as at Mendota. On the same mountain, in Bland county, the increased thickness is noticeable even to the most careless observer, and on the road leading from Walker creek to Hunting Camp creek, the following succession was seen:

1. Sandstones with some shales.
2. Conglomerate sandstone.

* Loc. cit., pp. 44 and 45.

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3. Shales and sandstone.
4. Conglomerate sandstone.
5. Shales and flags.

No effort was made to secure measurements here, as the road is tortuous and in unbroken forest, but an excellent section can be obtained by instrumental measurement, as the stream bed affords almost continuous exposures below the upper conglomerate. The flaggy sandstones between the conglomerates are bluish red and resemble closely the rocks immediately overlying the upper conglomerate; but details respecting the great part of No. 1, which includes beds of passage from Vespertine to Chemung, are practically wanting here. In the Laurel Fork gap through Brushy mountain in Smyth county, and in the Seddon gap in Bland county, these are shown to be gray to blue sandstones.

The section is similar in the Little Walker mountain gaps. On New river the distance from the "Quarry rock" to the conglomerate is not far from 900 feet, but no exposures occur in the interval along the railroad. Almost continuous exposures on the Newport and Christiansburg road show the space to be filled with gray to yellowish flags and sandstones with few shales.

At all localities the beds of No. 3 consist of more or less argillaceous concretionary sandstones passing downward into shales with bluish red or deep red flaggy sandstone. The flags, though forming a small part of the mass, are sufficiently hard to support the cliffs of this division, which are seen in many ravines. These beds are well exposed on all graded roads crossing Brushy and Little Walker mountains; along the ravine followed by the road to Hunting Camp creek, in Bland, they are shown in cliffs. There, however, the flags appear to be more abundant than at any other locality. No satisfactory estimate was made of the thickness, but as exposed along the Hunting Camp road, in Bland, it is not less than 1000 feet.

No. 5 consists of flags and shales, olive, gray, blue and drab, which are well shown at many localities.

The conglomerates are rarely shown in place. No. 2, which is not far from forty feet thick on Brushy mountain and is certainly much thicker in Little Walker, was seen in place only on the road to Hunting Camp creek, on New river and on the Newport and Christiansburg road over Little Walker, yet this conglomerate is the "backbone" of both mountains, and to its ragged outcrop is due the irregular crest of each. Its fragments are always abundant and ordinarily they are characteristic. The pebbles vary in size from a pea to a hen's egg; while in several of the layers they are flat and, curiously enough, in some parts their longer axis is almost vertical to the plane of bedding. Almost without exception these are of quartz or quartzite. The lower conglomerate was seen in place only on the Hunting Camp Creek road in Bland county, just where the road leaves the long gorge and emerges upon the "clearing." In general features it closely resembles the upper conglomerate.

In the New River section fragments with Chemung fossils are plentiful to a vertical distance of not far from 500 feet above the conglomerate, but beyond that the fossiliferous fragments become rare and soon are altogether wanting. A fossiliferous sandstone containing *Chonetes* and *Pthonia*, both Chemung forms, together with many other forms not easily recognizable on the weathered surface, was seen on the Dublin and Pearisburg pike at between 300 and 400 feet vertical distance above the supposed place of the upper conglomerate. The transition thence to the Vespertine, as shown in the excellent and almost continuous exposures along that road, is absolutely imperceptible—there is no change to the "Quarry rock," and the drawing of the line of separation at the bottom of that rock is wholly arbitrary here. But at many other localities a change occurs at about 200 feet below that rock, bringing in some bluish sandstones. Chemung forms become very abundant immediately below the upper conglomerate. Good collections can be made on Brushy mountain in Bland county along the Seddon and Mercer road, as well as along the road from Point Pleasant to Kimberling creek. Excellent localities on Little Walker are on New river and on any of the roads crossing the mountain in Pulaski and Wythe counties. No doubt good collections can be made within a mile and a half of Pulaski on the road leading over Draper mountain.

The geologist familiar with the Chemung of Pennsylvania and Maryland will recognize a familiar section here: the two conglomerates with variegated shales below them passing into the flags, while between them are the flags and shales passing through clayey concretionary sandstones to the upper conglomerate. The similarity fails above that conglomerate in that the red shales are wanting, and the passage to the Vespertine is through sandstone rather than through shale. The condition is more nearly that of South-western Pennsylvania where, as here, the Catskill is absent and the Chemung is carried directly to the Vespertine. The thickness of the section in Bland county appears to be very nearly the same with that of the section in northern Bedford county of Pennsylvania, nearly 300 miles away along the line of strike. This persistence through so great a distance makes more remarkable the entire disappearance of the group between Bland Court-house (Seddon) and Pennington's gap in Lee county, only 125 miles away at the south-west.

This group evidently reached to the south-easterly side of the "Great valley," for the beds upturned alongside of the Draper Mountain fault are within twelve miles of the Archæan.

Hamilton.—The line between Hamilton and Chemung cannot be drawn satisfactorily during a reconnaissance, as the passage from one to the other is by no means abrupt. So gradual, indeed, is the passage here, as well as in a great part of the Appalachian region, that the older geologists of both Virginia and Pennsylvania placed the series together as a single group, their No. VIII. The Hamilton shales are gray to black, and evidently represent only the lower part of the group as found further northward. They are shown in the "Poor valleys" of Walker and Cove mountains,

as well as in Bland county around the foot of Round mountain. They contain little of interest.

The Upper Silurian.

No definite line of separation between Upper Silurian and Devonian could be made out except in the "Wilderness" area of Bland and Giles counties; there the Oriskany is present, which makes the boundary distinct. Upper Silurian, represented by Oriskany, Clinton and Medina, makes up the most prominent features of the district, Medina being, *par excellence*, the mountain-making rock.

The *Oriskany* was seen only in Bland county, where it is exposed at the foot of Round mountain and the Garden mountains, as well as along the foot of Wolf Creek mountain in the "Wilderness." The rock is a thin sandstone, which resists the weather so well as to make a small ridge. If this rock be present in the "Poor valley" between Big and Little Walker mountains, it must be very thin and must yield readily to the weather, as that valley was crossed on four lines, each affording good exposures, but without Oriskany. As shown in the "Wilderness" the rock is a moderately coarse gray sandstone, evidently not more than ten feet thick, and containing, in addition to the ordinary forms, impressions of large crinoidal joints.

The *Lower Helderberg* may be present in the "Wilderness," but no positive proof exists. Fragments of white chert containing a delicate *Stromatopora*, and seen near Round mountain, have much resemblance to the chert bed at the base of the Oriskany or top of the Lower Helderberg. Aside from those fragments nothing referable to the Lower Helderberg was seen in any of the "Poor valleys."

The *Clinton* forms a bench around Round mountain; on the Garden mountains; on Wolf Creek mountain and its continuation in Pearis and Sugar Run mountains; on Big Walker and Cove mountains. Everywhere it presents the same features, variegated shales with white sandstones near the ores. The "fossil" ore occurs, but little only is known respecting either its quantity or quality. It appears to be abundant, though silicious, on Wolf Creek mountain, if one may judge from the fragments where the ore horizon is crossed by the road near Wolf creek or Rocky gap.

The *Medina* is well known as the mountain-making rock. Its outcrop forms the crest of Cove, Big Walker, Garden, Round and Wolf Creek mountains; it makes a double outcrop on Pearis and Sugar Run mountains, as well as on Butte and Salt Pond mountains; while it is shown on each side of the House and Barn synclinal in Buckhorn and East River mountains.

The *Upper* or *White Medina* is very far from being coarse, though a few layers of conglomerate were observed in it. The best exposure is in the gap made by New river through Big Walker mountain, where the estimated thickness is 375 feet. For the most part the rock is white, and on long exposure the surface becomes beautifully polished. This is char-

acteristic of the rock along an outcrop of fully 400 miles. Some brown or reddish-brown layers occur in this division, but their thickness was not ascertained. Aside from *Arthrophycus harlani* and a *Scolithus*-like form, no fossils occur in the sandstone.

The *Lower Medina*, composed of reddish sandstones and shales, is the imperfect terrace on the northerly side of the mountains, and, as was stated in a previous memoir, this is clearly the same with the Terrace group of South-central Pennsylvania, which has been identified by Lesley, and therefore by the writer in his Pennsylvania report, as the Red Medina of New York. The thickness cannot be given with any degree of certainty, as the rock passes downward without break into the Hudson ; ordinarily it is much disturbed. The best exposure in detail is on the Tazewell and Wythe pike as that road descends the northerly side of Big Walker mountain toward Sharon Springs. There, within 100 feet vertically below the White Medina, is a fossiliferous bed, six to eight feet thick, containing *Rhynchonella, Orthis, Modiolopsis, Avicula emacerata, Ambonychia radiata* and fragments of *Orthoceras*, which were collected during an examination lasting but a few minutes.

The relation to the Lower Silurian, therefore, is intimate, so intimate that the writer is more than ever convinced that there is room for doubting the accuracy of any identification which makes the Terrace group of Southern Pennsylvania the equivalent of Medina in New York.

The Lower Silurian.

The Lower Silurian is represented by Hudson, Trenton and Knox limestone. Hudson beds occur only on the steeper slopes of the Medina mountains ; Trenton is at the foot of such mountains, but within the counties described in this memoir, is rarely seen in the broader limestone valleys. The Knox limestone is the surface group in the "Rich valley" of Bland and Giles ; on both sides of New river in Giles county ; and is the great limestone group cropping out over so much of the "Great valley" in Wythe, Pulaski and Montgomery counties.

The Hudson consists of red to yellow sandy shales, which pass with equal indefiniteness into the Red Medina (?) above and into the calcareous shales of the Trenton below. The Trenton beds are calcareous shales with streaks of impure limestone passing downwards into pure massive limestones, some of which would be valuable as marbles. The lower beds become more or less silicious and show embedded nodules of chert.

These cherty beds afford transition to the Knox limestones, which are very cherty in the upper portions. The lower portions contain much shale with silicious limestones, and near the base is a curious limestone, somewhat silicious, which is veined with white spar and contains great blotches of the same material. This is a notable bed, which is recognized in many places where it promptly affords a key to the puzzles. Its presence on New river and at several other localities in Pulaski county shows the relations of the rocks on both sides of the Walker and Pulaski faults, and

proves the presence of Knox beds in that part of Pulaski county lying between the Altoona railroad and New river. A good section of this group should be obtained along the Valley pike in Wythe county beyond Reed creek, beginning near Kent's Mills, where the series is well exposed almost to the fault of Draper mountain.

Along the southern side of Wythe and Pulaski counties, the Knox beds, more or less dolomitic, carry important deposits of zinc and lead ores, some of which have been utilized. The mine of the Wythe Lead and Zinc Company will be described in its own place. There the lead ore has been worked for more than a century, but the zinc ore had been neglected until the near approach of the Cripple Creek extension of the Norfolk and Western railroad led to its development and preservation. The zinc ores at the Bertha mine, also in Wythe county, yield a spelter of the finest quality. This strip of zinc and lead ores extends from Smyth county across Wythe and Pulaski, but developments thus far have been confined to Wythe county.

The brown hematites of the Knox limestones in Pulaski and Wythe counties, along the New river and its tributary, Cripple creek, have been well described by Mr. A. S. McCreath,* who examined most of the openings and analyzed the ores, using samples collected by himself. The ore lies not far from the lead and zinc, and appears to be present in great quantity. Much of it is of excellent quality.

Manganese oxide and barytes are reported as occurring at several localities, but no information was received respecting the quantity.

The Cambrian.

Here are placed the Lower Knox shales and the Potsdam. The former are probably equivalent to the Hydromica schists of Pennsylvania and the lower part of the Calciferous of New York; the latter is the Potsdam of New York, vastly increased in thickness.

The Knox shales are shown in Draper valley, within Wythe and Pulaski; they surround Lick mountain in Wythe and continue for some distance eastward along the anticlinal; they are continuously exposed within a mile of the southern border of Wythe and Pulaski counties, and are brought up for a little way under an anticlinal lying south from the Wytheville synclinal.

For the most part these shales are reddish, sometimes streaked with white, usually more or less greasy, often talcose-looking on the slipped surfaces. The rock is hard and is used for repairs of the Valley pike. An admirable exposure occurs on that pike for some distance east from the Cripple Creek railroad crossing, and one almost equally good is on the road crossing Lick mountain on the way from Wytheville to Brown Hill furnace. Streaks of limestone occur in the upper part, but they are wanting below. In the upper part are also some beds of yellow and blue shales,

* The Mineral Wealth of Virginia tributary to the lines of the Norfolk and Western and Shenandoah Valley Railroad Companies. 1884.

but they are thin. These shales are hard enough to form bluffs; where they have been long exposed to the weather, their surface becomes very dark and the dismal effect is increased by the abundant growth of ashen lichens, which are never absent from the older outcrops. The thickness of the group cannot be determined without careful study, as at all localities crossed the beds are badly folded; but it cannot be less than six hundred feet.

The Potsdam forms the great mass of Lick mountain; is the sandstone of Draper mountain; and is found along the southern border of Wythe, Pulaski and Montgomery counties. The upper beds are alternations of sandstones and shales. The sandstones are mostly white, vary from slightly conglomerate to exceedingly fine grain, almost like quartzite; many layers are hard and on long exposure become beautifully polished. The lower beds shown in the deeply eroded gorges of Lick mountain and on the northerly side of Draper mountain, are sandy shales, mostly grayish and often so thickly bedded as to be shaly sandstones. The bottom of the group is found not far from the line of Grayson and Carroll counties, but that line was not reached by the writer. No measurement to determine the thickness of the group was attempted, as the bottom is not exposed in either Draper or Lick mountain, but in Draper the thickness is not less than 2000 feet, the calculation being based on the dip and a rough estimate of the horizontal distance through the mountain from the fault to the bottom of the Knox shales. The amount of rock exposed along the road traveled over Lick mountain is not so great, but the deeper ravines of that mountain should show an equally extensive section.

No fossils were observed in the Knox or Potsdam shales, but the search for them was not diligent. Some layers of sandstone near the bottom of the Potsdam sandstone yield *Scolithus linearis* abundantly on Lick mountain; but neither that nor any other fossil was seen in the Potsdam of Draper mountain.

Ores of manganese and iron are reported as occurring near the bottom of the Knox shales, but no effort has been made to develop these except in a small way on Lick mountain.

III. THE REGION NORTH FROM BIG WALKER'S MOUNTAIN, BLAND AND GILES COUNTIES.

In descending Walker's mountain by the Wythe and Tazewell pike, one leaves the Medina at the summit and comes to a fossiliferous bed at barely one hundred feet vertically below the mountain crest. This is from six to eight feet thick and contains many typical Hudson fossils in great numbers; *Rhynchonella increbescens, Orthis occidentalis* (?), *Avicula emacerata, Ambonychia radiata, Modiolopsis* with fragments of *Orthoceras* were collected within a few moments. Other fossiliferous beds were seen lower down the slope, but no specimens were taken. These reddish shales with streaks of sandstone pass gradually into the yellowish shales of the Hudson, which in turn pass into the dull reddish calcareous shales or shaly

limestones of the Trenton. The cherts at the base of the Trenton or top of the Calciferous are reached at the first house. Thence exposures are rare until at the Sharon Springs some sandstones with indefinite dip are shown in the stream. These springs, which are the sources of the North Fork of Holston river, are very large and issue from very near the Saltville fault. The place was a popular summer resort in former times, but the construction of the railroad through the Great valley made it practically inaccessible and the hotel has few visitors.

The Saltville fault passes very near the yard at Sharon Springs, the ridge behind the hotel being sandy. The dip where the pike passes through this ridge is southward at fifty-eight degrees, and the silicious limestone of the Vespertine is shown at the northerly foot of the hill. The lower beds of the Vespertine have been eroded near the pike, but at a fourth of a mile eastward they form a low hill, in which a coal bed was mined at one time to supply local needs. The pits have fallen shut and most of them appear to have been little more than extensive strippings along the outcrop. The thickness varies greatly; it is reported as eleven feet at one place. The coal is badly twisted, but the crushing and polishing are much less than at many other localities. Notwithstanding this crushing, the volatile matter is considerable and the coal cokes on the fire. The rocks enclosing the coal are regular and not much distorted except at one place, where the distortion may be due to a surface creep.

The Tazewell pike continues northward, crossing Garden mountain, and, within a direct distance of four miles, entering Burk's garden, to which reference was made in the notes on Russell and Tazewell counties. This road was not followed beyond the abandoned coal-pits.

The Rich Valley road is near the top of the Calciferous until six or seven miles beyond Seddon, where it crosses the Saltville fault; but within a little way it returns to the Calciferous and remains in it. The Calciferous limestones and shales are apparently non-fossiliferous; certainly fossils are rare, none having been seen, though the exposures were examined for several miles. The dips vary from twenty to forty degrees, the more common rate being not far from thirty. Waddell's lead mine, abandoned long ago, is a group of rude excavations in Calciferous at five or six miles east from Sharon Springs. The road leading to Hunting Camp creek leaves Rich valley at nearly seven miles from the springs. The dips quickly steepen on that road, so that limestones exposed in the little stream-bottom near the first house are dipping southward at from fifty to sixty degrees. The Saltville fault is reached at barely half a mile, at top of an abrupt grade beyond the first house.

The blossom of a thin coal bed, indicating a thickness of not more than ten inches, was seen at the top of the first hill, which may be the same with a thin bed digged in the bed of a run not far west from the road. The silicious limestone is exposed at R. Waddell's house and a coal bed is worked in a small way by Mr. Harmon, very near the summit of the road, which is far from being the summit of Brushy mountain. The pit

was not examined and the thickness of the bed, which is said to be between three and four feet, was not ascertained.

The road descends rapidly on the northern side to a large branch of Hunting Camp creek, which follows a long gorge through Brushy mountain. The *upper conglomerate* of the Chemung is shown soon after the stream has been reached and forms a ridge on each side of the road; the exposed thickness is not far from forty feet. The layers of conglomerate are distinct and one of them is ferruginous, with pebbles as large as a walnut. The gorge below this is exceedingly rugged, the shaly beds of the Chemung being held in cliffs by thick flags which are shown nicely in the stream so often crossed by the road. A second gray sandstone, with layers of conglomerate and closely resembling the former, is shown just above the mouth of the gorge. The more shaly beds at the base of the Chemung are shown as one approaches Hunting Camp creek, at Mr. Soutter's. There one sees, in looking back, that the tributary streams have cut Brushy mountain into parallel ridges, each with one of the harder Chemung sandstones for its crest.

The lower shales of the Chemung with their hard flags form a low but very distinct ridge, which follows the foot of Brushy mountain and curves round the easterly end of the Garden anticlinal to form a similar ridge for a little distance between Round and Rich or Wolf Creek mountains. The Hamilton shales, which can be hardly separated from the Chemung during a hasty examination, continue to the northerly side of Hunting Camp, where the road first reaches it, though at a little way further down the stream cuts almost to their base. The Oriskany sandstone is exposed just north from the creek at barely a mile below Mr. Soutter's and thence its fragments are very numerous. The rock crosses the end of Round mountain as the Burk's Garden anticlinal dies away, and it is shown in the road at a short distance above the mouth of Hunting Camp creek. The most notable fossil is the stem of a *crinoid* of which individual joints are extremely common. *Spirifera arrecta* appears to be more abundant than any other of the ordinary forms. Evidently associated with the sandstone, but not seen in place, is a white chert, which contains a delicate *Stromatopora*. Whether this represents the Lower Helderberg or not could not be determined.

The road to Seddon leaves Hunting Camp creek at about two miles from its mouth and crosses Brushy mountain to Rich valley, at Seddon. The shales northward from the creek on this road are without doubt largely Hamilton, but beyond the creek southward the road quickly enters the low ridge of olive shales and flags, which has been referred to already as persistent along the foot of Brushy mountain for fully twelve miles. As the road ascends the mountain, it passes over olive flags with olive, gray, ashen, blue and yellow shales, continuing to the summit of the road; the southward dip being somewhat irregular, but rarely falling below twenty, or rising above forty degrees. These shales show no fossils aside from occasional impressions of crinoid joints and rude traces

of fucoids on the surfaces of the flags. Similar shales and flags continue for a little distance down the southerly side of the mountain, but the upper beds are soon reached and some of them are very fossiliferous. On one slab *Rhynchonella orbicularis*, (?) *Grammysia subarcuata*, *Modiomorpha*, *Mytilarca* and *Edmondia* were seen and the specimens were remarkably well preserved. The gray sandstones of the group are not exposed along the road, but their fragments are very abundant and the rocks themselves form the summits of the subordinate ridges. The Kimberling anticlinal is crossed at less than half way down the mountain and brings up again at least one of the sandstones. The passage to Vespertine is not easily made out. A mass of red sandstone occurs in a narrow gorge, say half a mile from Seddon, which probably marks the bottom of the Vespertine. Coal belonging to that group has been mined in a small way at half a mile west from Seddon and at about the same distance north-east from that village. A mine has been opened for domestic use at about three miles further east; but none of these pits was visited. The topography is reversed on the road crossing Brushy mountain, the long gorge being on the southerly side.

The road in Rich valley lies in Calciferous for somewhat more than six miles from Seddon or to a little beyond Point Pleasant. The chert ridge is south from the road and attains to considerable height in its eastern extension. The road lies south from the Saltville fault to Point Pleasant, but almost directly beyond that place it turns northward and thence to the road crossing the mountain to Kimberling creek it lies north from the fault. The dips in the limestone seldom exceed thirty degrees, except near the fault, where they become fifty-five and sometimes even more. Exposures are very indefinite along the road to Kimberling creek, as it ascends the slope of Brushy mountain. No coal blossom was seen and no coal is digged anywhere near the road. Fragments of the Chemung *upper conglomerate* are very numerous at the first summit of the road and the rock forms the crest of the first main ridge. Between this and the second or main summit of the road, fossils may be obtained in considerable quantity, *Rhynchonella*, *Chonetes*, *Grammysia* and *Goniophora* all well preserved, having been obtained from a single block. *Ambocoelia* occurs in vast numbers, its casts forming the mass of several thin beds. From this summit to Kimberling creek, the road is in the shales and flags which are exposed almost constantly thence to the mouth of No-Business creek. The dip is steadily southward, but becomes comparatively gentle along the creek, being barely ten degrees at the mouth of No-Business. There Kimberling changes its course to south-east and evidently flows through Devonian to where it crosses the Saltville fault at two or three miles east from Mechanicsburg. The stream was followed only to within about four miles of the fault so that the limits of groups as given on the map are only approximate. Dismal and No-Business creeks, tributaries of Kimberling, take their rise respectively in Sugar Run and Pearis mountains, double outcrops of Medina with Clinton between the outcrops: but the streams

enter Kimberling in Devonian, which is the surface group in nearly all of the broad space between Brushy mountain at the south and Wolf Creek mountain at the north, the distribution being due to the disappearance of the Burk's Garden anticlinal and to the growth of the Kimberling anticlinal. The portion of the area lying north from Kimberling is almost uninhabited and is known as the "Wilderness."

Exposures are very indefinite along the Wilderness road for some distance from Kimberling creek on the way to Rocky gap; but near Mr. Benton's house, at, say, two miles from the creek, the rocks are dipping northward at nearly fifty degrees, and the rate increases at a little distance further, as is well shown by exposures in the stream.

The dip again becomes southward at somewhat more than a mile from Benton's house and the Chemung rocks are soon shown with almost vertical dip forming an irregular broken ridge. No exposures aside from those of a few dark shales occur in the interval to the next ridge, a space which should be occupied by Hamilton. A sandstone ridge, evidently Oriskany, is cut by the road at somewhat more than a mile and a half from the Rocky gap by which Wolf creek passes through Wolf Creek mountain, the same with that known in Tazewell county as Rich mountain. This ridge is cut by the creek at, say, three-fourths of a mile from the forks of road at head of the gap. No fossils were observed in the sandstone. Some white chert which may represent the Lower Helderberg was observed here.

The Clinton is quickly reached with its dark red sandstone; it makes a well-marked ridge and terrace along the southerly foot of Wolf Creek mountain. Fossil ore occurs very abundantly, but the fragments seen along the foot of the mountain are very silicious. Medina is shown in the stream-bed at the very head of the gap, whence it rises rapidly to crest of the mountain with a dip of twenty-five to twenty-seven degrees. The immediately underlying red beds are more silicious than at most of the localities visited, and they are exposed to a thickness of about 250 feet. Exposures are very indefinite beyond this until the Trenton is reached midway in the gap. The Calciferous beds next come up and at the mouth of the gap they are dipping southward at thirty-five degrees. These beds prevail to the cross-roads at J. D. Honaker's store.

Wolf creek bends northward immediately below Honaker's store and soon crosses the Wenonah fault, which brings Calciferous against Clinton, the dip of the latter being eighty degrees. The Medina caught in this double fault forms the Valley ridge, which is persistent thence to the New river. The creek passes through this ridge at say a mile and a halt below Honaker's and affords a fine exposure of Medina on the easterly wall of the gap. The Calciferous limestones are reached immediately behind the ridge and within one-fourth of a mile are faulted against the Medina of Buckhorn mountain, a low ridge following the southerly foot of East River mountain. The road crosses this fault to the Medina, but returns to the limestone on the hill opposite Mr. Carpenter's house about

three miles from J. D. Honaker's store. Thence to New river the road is in the limestone between the two faults. The creek approaches the Buckhorn fault very closely near the line of Giles county, but the Wenonah fault, whose course is marked by the Valley ridge, is touched nowhere by Wolf creek below the gap near Honaker's. The dips in limestones between the two faults vary greatly, being from fifteen to forty degrees along the creek; but the rate diminishes toward New river, where it rarely exceeds twenty degrees. Though underlaid by limestones and calcareous sandstones, much of this Wolf Creek valley is very poor. Great fragments of Medina are numerous and the disintegrated sandstone has contributed most largely toward formation of the detrital covering.

The valley between Buckhorn and East River mountains is reported to be "freestone." No examination of its structure was made, but there appears to be a synclinal here, in which case the surface rocks would be Silurian shales.

The valley is contracted near the mouth of Wolf creek and the locality is known as the "Narrows." The crest of Wolf Creek mountain is carried northward in a bold knob which overlaps the Valley ridge. Thence it recedes southward, limiting the broad deep valley of Mill creek, to return northward and form the bold knob of Pearis mountain. The point of this mountain is at about two miles from Pearisburg and there the Medina outcrop curves southward under the influence of the Kimberling anticlinal. The Valley ridge becomes indistinct where the fault is crossed by the pike near Wenonah station. Thence to Pearisburg the road lies in Calciferous and Trenton limestones. The synclinal north from the Kimberling anticlinal is crossed by the Dublin pike at the southerly end of Pearisburg and in this is the "Angel's Rest" or terminal peak of Pearis mountain. The outcrop of Medina climbs the anticlinal as the fold declines, crosses it at the head of Sugar run and then moves eastward along the southerly side of the anticlinal. It soon recedes toward the west as it ascends the weakening anticlinal of Sinking creek and finally disappears against the Saltville fault.* That fault is crossed by the Dublin and Pearisburg pike at a very little way north from Poplar hill, where the Trenton and Calciferous are in contact and the road passes into the Rich valley between Big Walker's mountain and the Saltville fault.

A road, leaving the pike north from Poplar hill and leading to New river at Scott's ferry, crosses the Saltville fault at four miles from the pike or at a little more than one mile by Walker's creek above Staffordsville. Erosion here, as on the pike, has cut away all rocks higher than Trenton limestone from the north side of the fault, but, within a short distance, the Medina appears again and forms Buckeye ridge, the northern boundary of Rich valley to and beyond New river. The dying away of the Walker's Creek anticlinal permits the Walker's Mountain outcrop of Medina to advance northward so that the valley is narrow near New river.

* This outcrop was not followed to the Saltville fault and the statement given in the text is based on the topography.

The many railroad cuts along New river from this gap northward to Big Stony creek exhibit the structure very well. Only Calciferous is shown under the Kimberling and Sinking creek anticlinals until the Wenonah fault is reached near the mouth of Big Stony creek, where one sees Medina. Thence to the foot of Buckhorn or Little mountain the limestone is exposed in cuts and less frequently in natural outcrops.

The surface of the area between Pearis and Sugar Run mountains on the westerly side, and the Salt Pond mountains on the easterly side of New river shows traces of erosion planes. The underlying rocks belong to the Calciferous, Trenton and Hudson, but the detrital coat is very thick and for long distances completely conceals the bedded rocks.

The Buckhorn fault is continuous eastward from New river certainly for twelve miles and the limestones of the Calciferous are exposed frequently along Big Stony creek. The fault runs along the face of Buckhorn or Little mountain, but what becomes of it or of the limestone valley just south from it was not ascertained as the creek was followed only for three miles from the river, but the valley appears to be continuous to the county line. Big Stony creek approaches very closely to the Wenonah fault at barely a mile from the river, where the limestone is turned up suddenly at forty degrees northward and Medina is shown in the hill above.

A road leading to Little Stony creek leaves this stream at rather more than two miles and a half from the river. The Medina of the Valley ridge is reached before one comes to the first house, being shown in place at a little way from the road. The summit of the ridge is about 600 feet above New river at Snidow's lower ferry and there the Medina is reached a second time. The rock is not shown in place, but the surface is covered with fragments of the sandstone which could hardly have come down from Butte mountain. The limestones are reached again as the road descends to a little stream and they are still dipping southward.

The Trenton shales and shaly limestones are shown on the next ridge, but the Hudson beds are shown only further up the ridge eastward from the road. The summit of the road, at approximately 400 feet above the river at Snidow's lower ferry, is covered with debris of Medina and this ridge is merely the termination of Butte mountain. The Pearisburg synclinal passes at somewhat more than a mile from Little Stony creek, and the northward dip is well shown on the road as it descends to the creek. The Trenton limestones form a bold ridge on the southerly side of the creek, the southerly wall of a deep gorge which has Butte mountain for its northerly wall. Medina forms the double crest of Butte or Big mountain. The northerly outcrop encroaches on the narrow strip of Cambro-Silurian between the mountain and the Valley ridge so that the two lines of Medina appear to overlap. The area of the lower rocks is certainly so narrow that it cannot be represented on the map.

The road to the Mountain lake leaves the pike at Doe creek, which it follows to very near the lake. The cherts of the Calciferous are exposed

at the pike and the axis of the Kimberling anticlinal must pass near the fork of the road. The Lake road winds up the mountain side and reaches the Hudson beds within two miles of the lake. The Pavilion Knob, just west from the lake, shows the red shales with *Rhynchonella* and *Ambonychia* half way up, while at the very top is a large Lingula in vast numbers associated with a *Modiolopsis*. Medina caps several knobs on the ridge between Doe and Little Stony creeks. The outcrops of that rock meet on the summit of the Kimberling fold at a considerable distance east from the lake and thence to the eastern edge of Giles county Big and Salt Pond mountains are covered by dense forest, through which no road passes.

The Mountain lake or Salt pond is at somewhat more than 4000 feet above tide and is three-fourths of a mile long by one-half mile wide, the measurements being extreme in each case. It occupies a great sinkhole, which, within fifty years contained only a small pond of water at the bottom of the depression, by which a farmer salted his cattle. In some way, the outlet of the pool became choked, and water from the adjacent springs accumulated until it overflowed the rim and discharged itself into Little Stony creek. The subterranean outlet may be opened again and the pond drained. The spot is very attractive, and at one time it was a popular resort.

The road to Newport winds along the side of Salt Pond mountain, descending rapidly after it passes the point of the mountain, which is in the synclinal between Kimberling and Sinking Creek anticlinals. The Trenton shales are reached at about three miles from the Lake hotel and are thrown into numerous and complex folds, many of which are broken and slightly faulted along the axial plane. These occupy the synclinal and exhibit conditions the same with those observed in these shales in the Pearisburg synclinal on the point of Butte mountain. The massive beds of the Trenton are reached quickly after the road begins direct descent to Sinking creek, but exposures soon become rare, as the surface is thickly covered by debris, derived largely from Medina, of which huge fragments are numerous. The Calciferous cherts are shown occasionally, but not in place.

The Sinking Creek anticlinal is crossed at not more than two-thirds of a mile north from that creek, and the massive limestones of the Trenton are shown at the stream with southward dip. The pike is reached at a little way beyond the creek, and there the Trenton shaly limestones are shown much distorted and describing many complicated folds; the dip on each side being often eighty degrees. The thicker limestones are brought up several times. The road crosses the Saltville fault at a little more than half a mile north from Newport, the Trenton shales being brought into contact with the lower cherts of the Calciferous. The fault passes along Buckeye mountain, which, where crossed by the pike, has suffered much from erosion; but at a little distance on each side the Medina is present and the mountain is conspicuous. The Sinking Creek anticlinal diminishes eastward and the Medina outcrops unite before reaching the county line.

Rich valley widens between New river and Newport. The dips in its limestones are from fifty to sixty degrees. The massive beds of the Trenton are shown on Gap or Big Walker's mountain with this dip, and Medina at the summit shows a dip of sixty degrees. Exposures are very good on the northerly side of this mountain.

IV. THE COUNTRY SOUTH FROM WALKER'S MOUNTAIN, EMBRACING PORTIONS OF WYTHE, PULASKI AND MONTGOMERY COUNTIES.

By far the greater part of Wythe county south from the Norfolk and Western railroad shows only rocks belonging to the Knox group, but the Potsdam is brought up along the southern border of the county, as well as at a little way from the railroad, in a bold east and west ridge, known as Lick mountain. In going southward from Wytheville, one finds the Knox limestones so much twisted as to suggest that the Draper mountain fault has not wholly disappeared. The Knox shales are shown within two miles from the railroad, where the road enters Lick mountain and the Potsdam beds at not many rods further. The sandstones of this great group form the hog-back ridges, of which the mountain is made up, while the shales are exposed in the deep ravines. The sandstones are passed at about eight miles from New river, where one comes again to the Knox shales, which are badly distorted.

On the road leading to the Wythe lead and zinc mine, which is reached at about two miles from Cripple creek, the rocks are concealed for long distances by the thick cover of terrace debris; but the Knox limestones are well shown in the river bluffs, at the Wythe lead and zinc mine, both above and below Thorn's ferry, where the New river cuts a fine anticlinal.

The Wythe lead and zinc company have their mine at Austinville, in Wythe county, nearly seventeen miles from Wytheville, or twelve miles from Max Meadows station. The ore was discovered and first utilized not far from 130 years ago, but systematic mining has been prosecuted for barely fifty years. The reduction works have a capacity of between 600 and 700 tons per annum, and are of interest, as they were practically the only lead works within the limits of the confederacy and yielded nearly all of the lead employed in the manufacture of bullets for use of the Confederate soldiers.

The lead and zinc ores occur in an enormous impregnation deposit and are extracted both by open cut and by deep mining. The conditions in the surface workings are approximately as follows:

1. Gray limestone.....25′

   The upper part shows a network of galena; some excellent blende almost free from galena is found midway; while lower down both galena and blende occur abundantly. The lower half of the rock, which had been digged extensively, is said to contain a large amount of both blende and galena; but it was concealed by a slide at the time of examination.

2. Gray sandy limestone.....10′
This appears to be barren.

3. Ore.....8′
This consists of carbonate and silicate of zinc associated with much galena. The calcareous matter has been leached out and the ore is in irregular honeycomb masses.

4. Limestone, evidently barren.....9′

5. Ore.....8′
The conditions are the same as those in No. 3.

6. Limestone, gray.....25′
This contains a very large amount of blende and galena, but the ore is not sufficiently concentrated to make working profitable.

7. Ore.....2 to 10′
The conditions in this are the same as in Nos. 3 and 5. The deposit shows more irregularity than was observed in the others.

8. Limestone, apparently barren.....10′ to 12′

9. Ore.....6′ to 10′
Here too the calcareous matter has been removed and the ore, which consists of zinc silicate and carbonate, with only a trace of galena, is cavernous.

10. Limestone, barren, seen.....5′

No further exposures occur. The upper edges of the limestone in this extensive stripping are rounded as though they had been exposed to long erosion, and the whole was covered with a tough reddish clay, fifteen to thirty feet thick, overlaid by slidden material, ten to twenty feet thick. For the most part the clay is barren, but sometimes it yields fragments of galena and altered zinc ores; and at a cutting just beyond No. 10 it has yielded a very considerable quantity of earthy carbonate of lead. These silico-carbonate ores are merely superficial, for at less than 100 feet from the surface in No. 9 blende occurs to the almost complete exclusion of calamine and smithsonite.

Though commonly spoken of as "leads," these deposits have no features entitling them to that name. The characteristics are well shown in surface workings made on this property by J. S. Noble in 1866, when he mined the zinc ore for shipment to New Jersey. These pits, at say half a mile from the tipple of the present surface workings, are on Bald hill, where erosion has removed the superficial material so as to expose the limestone over many acres. As the lease under which the work was done was short and as lump ore alone was to be removed, the deposit was worked only where richest and most distinctly marked; when it became indefinite the pit was abandoned and a new opening was made elsewhere. The whole area is pitted and the openings vary greatly in shape. Clearly no

systematic mining is possible in deposits such as this, and the only available method is follow ore, wherever found, until it ends.

The separation of the lead and zinc ores is effected by jigging. The ore, after crushing and grinding, passes to the jigs, which are in sets of four. The galena is almost wholly removed in the first, while the ores of zinc are separated by the remaining three. The separation is almost complete and the amount of escaped ore passing off in the tailings is insignificant. Much of the lead produced here is manufactured into shot of decidedly excellent quality, and an air-shaft, 262 feet deep, is utilized as the shot tower.

Along the road leading from Thorn's ferry to the Valley pike, exposures are few until Mr. Raper's house has been reached, but thence to the pike exposures are good. The Knox limestone is shown in the road near Mr. Raper's house and at a little way further the shales are at the surface. But a slight fault exists here, for the limestone re-appears within a few rods and continues until a short distance beyond the road leading to Walton's furnace. Thence to the pike the road lies in the shales and the Potsdam of Lick mountain nowhere reaches it. The beds seem to be thrown into two anticlinals, of which the more northerly is crossed near the last fork in the road, less than two miles from the pike, which is reached at barely seven miles from Wytheville.

Knox limestones, dipping west of north at sixty-five to sixty-seven degrees, are well exposed in Wytheville along the street leading from the railroad station to the court-house ; but exposures are very poor for some distance northward from the borough on the Wythe and Tazewell pike. The dip is soon changed on that side and the first good exposures show the south of east dip practically the same as the opposite dip on the other side of this Wytheville trough. The ridge on which the borough of Wytheville stands marks the course of the synclinal, which is cut off by the Max Meadows fault at a little way further east. The anticlinal north from this, in which the Max Meadows fault may originate, has been crossed before one comes to the blacksmith's shop two miles and a half from the court-house in Wytheville, for there the dip is northward at from twenty-five to thirty degrees ; but the place of the axis cannot be determined easily as the surface is covered with a thick coat of sands and clays.

The dip is changed again at somewhat more than two miles and a half from Stony Fork of Reed creek, the southerly direction being very marked at the S-curve in the road, while at Mr. Brown's house it is fifty-five degrees almost east of south. This direction of dip continues to the little valley in front of Stony Fork M. E. Church, where the Walker Mountain fault is crossed and one comes to the Umbral shales. The Knox limestone is well shown in the low hill, while shales are seen at its northerly foot dipping toward the fault at from thirty to thirty-five degrees. The shales are exposed occasionally at the roadside, and one comes to the silicious limestone at the Vespertine ridge, which forms the foothill of Little Walker mountain. The coal-bearing group begins below this limestone and its

red or brownish-red sandstones are shown for some distance southward from the ford.

Col. J. T. Boyd of Wytheville has opened several of the coal beds alongside of the stream as well as in a hollow coming down by Mr. Davidson's house. The numerous openings on the south side of the creek show fairly well the relations of the lower beds, the following section having been obtained:

1. Coal bed, V, said to be.....1′ 6″ to 2′
2. Interval, said to contain Coal bed, IV, 2′.....67′
3. Coal bed III, said to be.....1′ 7″
4. Sandstone and shale.....13′
5. Coal bed II, said to be.....6′ or more to 2′ 6″
6. Sandstone.....17′
7. Coal bed I..... 0′ 10″
8. Sandstone, seen about.....20′

Mr. C. R. Boyd, who has reported on this property, says that the interval, No. 6, becomes thirty feet at only a few rods from the locality visited. Coal beds II and III have been opened in a hollow above Mr. Davidson's house, where both are badly crushed, the lower much more than the upper. The roof shales have been crushed as badly as the coal at most of the pits, but at one under the road and alongside of the creek a fragment of *Lepidodendron* was seen, altogether without distortion; at all other points, however, the crushing and consequent distortion have practically destroyed all details of structure. The underclays are full of leaves or appendages belonging either to *Lepidodendron* or to *Stigmaria*.

The coal bed, II, has been opened at several places along its outcrop east from the creek, where it shows material variations in thickness and structure, due evidently to the pressure which the bed has undergone. The thickness at one opening appears to be more than four feet, but the structure could not be made out. A new cut showed

1. Black shale and coal streaks .....1′ 6″
2. Clay.....1′ 0″
3. Coal .....2′ 6″

Here there is apparently no distortion, but the crushing is no less severe than at an older pit where the bed has been twisted beyond recognition. The coal occurs in thin laminæ, easily separable and beautifully polished.

The "Quarry rock," the lowest bed of the Vespertine, which comes to the creek at the coal pits, is a gray, sometimes slightly conglomerate sandstone. The Chemung is not well shown in the gap through Little Walker mountain. The relation of Devonian to Upper Silurian is not altogether clear, as the Oriskany was not recognized in the "Poor Valley." Black shales, dipping northwardly, were seen nearly opposite Mr. Hedrick's house, which seem to be continuous thence to the final crossing of the stream, where they are associated with drab and yellow shales which contain fossil ore and are of Clinton age. From that place, the road winds for

three or four miles up the side of Big Walker mountain and for certainly half the distance is on Clinton which is thrown into many narrow folds. Where the Medina is first reached, the dips vary from fifteen to twenty-five degrees, but the rate increases, until at the summit the lower beds with *Arthrophycus harlani* dip south-eastwardly at forty degrees. Another form, like a *Scolithus*, penetrating a layer about ten inches thick, is seen at the summit. It is single at each surface of the layer, but forms a loop in the body of the rock.

The Vespertine beds form a foothill to Little Walker mountain and are faulted against the Lower Silurian rocks in Crockett's Cove of Wythe county as they are on Stony Fork of Reed Creek. But the Max Meadows fault crosses the strike and the eastern side of Wythe county shows a much longer continuous section than is found in the western part. On the southerly side of Crockett's cove the Trenton and Hudson beds pass upward into the short but bold Medina ridge known as Cove mountain, which is a notable feature of the scenery. Clinton forms the southerly flank of the mountain as well as the northerly side of the valley between Cove mountain and Max Meadows or Tract mountain, which lies north from the railroad between Max Meadows and Pulaski. The southerly side of the valley is occupied by Devonian shales passing upward into hard sandstones of the Chemung, which make the body of the mountain.

In following the Norfolk and Western railroad from Wytheville station eastward, one finds the north-westward dip continuous until the Knox shales are reached at about three and a half miles from Wytheville. Beyond that, exposures become few, but the road follows closely the line between the limestone and the shales until the Max Meadows fault has been reached beyond Max Meadows. Exposures are good and almost continuous between Max Meadows and Pulaski.

Some dark shales and impure limestones are exposed immediately beyond the former station and red shales are shown at and beyond the first small bridge. These are succeeded in the first cut by the dark limestone with veins and pockets of white spar, which lies at the base or nearly so of the Knox limestone. Owing to the direction of the railroad, this limestone is exposed until nearly two miles from Max Meadows. In a deep cut beginning there, the limestone has been replaced by a conglomerate, which may be of recent origin. It is not less than forty feet thick, has no definite bedding and is variable in composition, some parts breaking down readily on exposure, while others retain their shape and disintegrate very slowly. This may mark the course of an extinct stream.

The next cut, beginning at two and a half miles from Max Meadows, shows first a gray sandstone, quartzite-like in fineness of grain, which is succeeded by irregularly bedded reddish shales with thin streaks of sandstone, the dip being south-eastward at about fifteen degrees. The shales in the next cut are very red and somewhat fissile. These continue to Clark's Summit cut, which begins at somewhat more than four and a half miles from Max Meadows, where they are succeeded by reddish sandstone

and shales containing a thin coal bed. These have been thrown into petty folds and the coal bed has been the chief sufferer. It has been squeezed beyond recognition as a bed and the coal is laminated; but the lamination, unlike slaty cleavage, is rudely parallel to the plane of bedding.

The rock exposure ends abruptly midway in this cut and thence to the end, fully one-eighth of a mile, the material is a loose incoherent mass of clay and sand, loaded with fragments of sandstone, chert and a little limestone, all of the fragments being angular. This accumulation bears much resemblance to those containing "wash ores" in Bedford county of Pennsylvania. The limestone at the top of the Vespertine is shown in this cut very near the beginning of the rubbish.

The next cut shows the Vespertine rocks with a thin coal bed and with gentle dip. Some prospecting pits were sunk on the Clark property in search of coal, and, according to the report made to the writer, coal of fairly good quality was found in quantity to repay working; but no attempt to utilize the deposit has been made. The coal in the cut is too thin to be of any value, but the Hon. J. S. Draper states that beds of workable thickness occur on his property at a little way south.

It is sufficiently clear that the Max Meadows fault is crossed at not far from three and a half miles from Max Meadows, and that the red shales in the cut west from Clark's summit belong to the Lower Carboniferous.

Vespertine sandstones remain in sight to the Bertha Zinc Works, just west from Pulaski. Near the 86th milepost, or somewhat more than six miles east from Max Meadows, the blue sandstone is reached. This handsome stone has been quarried for building purposes; it has been used largely in railway masonry, and is the stone of which the Maple Shade Inn at Pulaski has been built. The rock is blue, fine-grained, cross-bedded and breaks with a conchoidal fracture. Where first seen it is exposed to a thickness of about twenty-five feet and contains many rounded balls of red clay or red shale scattered throughout the mass of the rock. The lower layer is less coarse but contains small pebbles of quartz and sandstone. No fossils were observed at any of the exposures.

This rock is shown along the railroad and Peak creek, forming bluffs alongside of the creek, and being quarried at several places on the railway. The thickness is not less than forty feet. Underlying it are shales and sandstones, the shales drab, gray to red, while the sandstone very closely resembles the more massive beds above. Some fucoids were seen in the red shales, but no other forms were observed.

The synclinal between Peak hills and Draper's mountain is crossed by the railroad at the tunnel near the second bridge over Peak creek, where the north-westward dip is twelve degrees. The sandstones of the group form a line of hills south from the railroad which are distinct from near Clark's summit to certainly two miles beyond Pulaski. The railroad runs on the easterly side of the synclinal to the Zinc Works. Between those works and the station passes the Pulaski fault, which brings the Vespertine into contact with almost the lowest bed of the Knox limestones.

Returning to Wytheville and taking the macadamized road leading thence to Newbern, one rides on the lower limestones of the Knox group until he crosses Reed creek, where the Knox shales are shown, still dipping sharply toward the west-north-west. The first good exposure beyond the creek is at the roadside near Kent's mill, where the limestones are shown with vertical dip, so that the axis of the anticlinal must pass at but a little way from the creek. The dip gradually decreases and within half a mile the massive limestones are dipping at from twenty to twenty-five degrees almost south-east. These limestones belong to the upper part of the Knox.

Half a mile further east, there being no exposures in the interval, Knox red shales were seen with almost vertical eastward dip. An exposure of sandy limestone, also with nearly vertical dip, was seen on the northerly side of the road at a little way further east, but thence the exposures are poor for several miles. The dip is reversed again near the Max Meadows road.

Where the road leaves Reed creek, at nine or ten miles from Wytheville, there is a close anticlinal whose formation was connected with severe disturbance, for the rocks are much crushed and there seem to be some petty faultings. The road turning southward soon rises to near the summit of the Lick Mountain anticlinal and follows it for a number of miles. The rock exposed for a long distance is the same limestone with veins and pockets of white spar, which is so well shown in the railroad cuts east from Max Meadows. It is associated with yellowish shales which are especially well shown in the cuts beyond the Pulaski road.

The chert ridge is double in the synclinal between the Lick Mountain anticlinal and Draper's mountain, and it forms an imposing knob near Reed creek, while one side of it forms a low persistent ridge between the pike and Draper's valley, terminating in a double knob at the eastern end of the mountain. This ridge is notched by many little streams which rise in the valley and unite to form larger streams only after passing through the ridge.

The Pulaski road leaves the pike at about twenty miles from Wytheville and crosses Draper's mountain. As it passes through the ridge of Draper's valley it shows the Knox limestones with easterly dip. The limestones end at a little way east from Mr. J. S. Draper's house, which is on the Knox shales. There the road begins to ascend the mountain and within a short distance sandy shales or shaly sandstone of the Potsdam is imperfectly exposed at the roadside. The next exposure, beginning at somewhat more than half a mile from Mr. Draper's house, is continuous to beyond the summit. This shows Potsdam sandstone dipping south-eastward at from thirty-five to fifty-five degrees, the average being not far from forty-five degrees. No fossils were observed in this sandstone, but the rock bears close resemblance to the Potsdam of Lick mountain as much in the intercalated brown or reddish-brown shaly beds as in the sandstone itself. There is nothing on either side of the mountain to answer to Hud-

son or Clinton, but on the northerly side is a mass of shale like that forming the lower part of the Potsdam on Lick mountain.

These underlying shales are well shown on the northerly side of Draper's mountain, where, for a few feet directly under the sandstone they are almost black; but for the most part they are grayish, sandy, and in rather thick layers, so that they might almost be termed shaly sandstones. Their south-easterly dip is as abrupt as that of the sandstone on the other side of the summit.

The Draper Mountain fault passes about one-third of a mile west northwest from the crest of the mountain, and on this road brings the lower beds of the Potsdam into contact with the lower Chemung shales. The Chemung sandstones form a bold ridge beyond the old Pepper road, in which the brownish beds contain many fossils. The Chemung conglomerate was not seen in place as the foliage was very dense, but its fragments are numerous. Vespertine beds form the next, a low ridge in which traces of coal have been observed and the bluish sandstones have been quarried. Thence for a little way there are no exposures, but in the bank behind the Maple Shade Inn the veined limestone of the Knox group is quarried, while just beyond Peak creek, immediately north from the railroad station in Pulaski, limestone belonging to the same group is exposed. These limestones are shown on the country road to the Robinson tract, a distance of about six miles, and that beautiful tract must also be underlaid by the Lower Silurian limestone; but no examination to ascertain this was made.

The limit between the shales and shaly sandstones of Devonian and Carboniferous at the west and Lower Silurian at the east was not followed out in detail, but it passes almost midway between the Altoona coal road and the county road in Pulaski; it is a little way west from the Poplar Hill church, four or five miles from Pulaski. Beyond that northward, it evidently lies east from the Altoona railroad.

The Altoona coal mines are in Pulaski county, at eleven miles by rail from Pulaski, though the actual distance is much less. The bed now mined is the second of the Vespertine beds, which varies in thickness from four to twenty-two feet, in the latter case including not a little shale. The pressure has crushed the coal to such an extent as to destroy in great measure its marketable value, but a large quantity is mined each year for use at the Salt works in Smyth county. At one time the third bed, said to be four feet thick, was mined here, but work on it has been discontinued, only a small quantity being taken out to run the locomotives on the coal road. The coal from this bed is far superior to that from the other.

A road follows the bottom of Peak creek for nearly two miles below Pulaski, and then leaves the creek to cross the easterly point of Draper's mountain to the Valley pike, which it reaches at somewhat more than a mile and a half southward from Peak creek. The Vespertine ridge is cut off by the Pulaski fault before this road reaches the line, but the Devonian ridge continues beyond the road. The Draper Mountain fault is greatly

diminished in strength and the Potsdam sandstone makes little showing along this road. That rock evidently extends to near Peak creek and the limestone on the north side of the Pulaski fault must be in contact with it near the creek.

Where the road reaches the pike, Knox shales are shown at the roadside with almost vertical dip. For the most part they are red, weathering dark brown and covered with lichens. With these are some yellow and blue shales, and streaks of impure limestone. The shales continue along the pike to beyond Peak creek, where one crosses the Draper mountain fault and comes again to the Knox limestones. An anticlinal was observed in Newbern, the county seat of Pulaski county. Thence to half a mile north from Dublin the limestones are dipping northwardly.

But a little more than half a mile north from Dublin, exposures practically cease and thence almost to Back creek very little is shown. The whole space is an old erosion plane and the bedded rocks are concealed under a deep cover of debris. The few imperfect exposures show only shales, which are dipping southwardly. These belong to the lower part of the Knox limestone and are the same with those exposed on the valley pike, east from the Pulaski road. Limestones are reached near Back creek and continue to perhaps half a mile or more north from that stream. The beds appear to be wholly without fossils, but their relations are clear enough and they belong to the lower part of the Knox limestone. The lowest bed is the dark limestone carrying veins and geodes of white spar, which is exposed for a long distance on the Valley pike, east from Reed creek.

After crossing Back creek, the road begins to ascend Cloyd's or Little Walker mountain and exposures are good. A great thickness of red shales comes immediately behind the geodal limestone and some of the upper beds are very like those of the Knox shale; but shales of very different character are soon reached, which belong to the Lower Carboniferous, to the Umbral period. The Vespertine or coal-bearing division is reached at a short distance below the Jennell place, where one of the beds has been mined to some extent. The blossoms of four beds are shown in the roadside, above the Jennell house, within a vertical distance of about 115 feet. The upper beds are not more than three or four inches thick, but the second is almost nine feet from rock to rock. It is said to contain one foot of good coal at the bottom, while the rest of the interval is occupied by alternating thin layers of coal and shale. The lowest bed is from two feet to two feet six inches thick, and is said to yield very good coal. This is said to be the bed worked by Mr. J. H. Tyler, two miles east from this road. That mine was not visited. The interval between the two beds at the roadside is about fifteen feet and is filled mostly with sandstone.

The lowest bed of the Vespertine is a gray sandstone, well-shown at the roadside. The passage to the Chemung is imperceptible through concretionary sandstone and shale, undoubted Chemung being reached in a fossiliferous sandstone containing *Chonetes* and other forms which are not

recognizable on the weathered surface. Concretionary sandstones continue below this and, at say 300 feet lower in the series, the upper conglomerate of the Chemung is shown, with not a few of its layers containing flattened pebbles. The concretionary structure gradually disappears below the conglomerate and many of the beds on the northerly side of Cloyd's mountain are fossiliferous. The conglomerate forms the crest of the mountain for nearly the whole length. The variegated flags and shale in the lower part of the Chemung are reached quickly on the northerly side of the mountain as the road descends to the valley of Little Walker creek. Exposures are fairly good in the valley and in the gap through Big Walker mountain, but Oriskany was not recognized, so that, if present, it must be very thin. Medina forms the great part of Big Walker mountain and is fairly well exposed in the gap made by Little Walker creek.

The Medina is well shown in the gap made through Big Walker mountain by New river, where it appears to be in all not far from 875 feet thick. Good exposures occur here between the mountains, but, if present, the Oriskany and Lower Helderberg are so thin that they escaped observation. The Chemung beds are sufficiently well shown to make the construction of a complete section by no means difficult to one doing systematic work; but no section was attempted by the writer, who began his examination near the top of the group.

The "point" of Cloyd's mountain in New River gap is at a little more than eight miles from New River station on the main line. There the Chemung conglomerate, which forms the backbone of the mountain, comes down to the river and is exposed in a railroad cut. Behind it for about 130 yards—beyond which no examination was made—fragments of the bluish-red sandstones of the Chemung are plentiful in the debris which covers the mountain side. Many of these fragments are fossiliferous and the locality will prove to be a good one for the collector. The sandstones are very hard and the fragments are used in ballasting the track from this place almost to New River station.

The upper conglomerate of the Chemung, as shown in this New River gap through Cloyd's mountain, is not far from thirty feet thick. Its upper part is well exposed, is about fifteen feet thick, very hard and coarse, with pebbles often as large as a hen's egg, mostly of quartz and frequently flat. In some of the layers the longer axis of the pebbles is vertical to the plane of bedding. The lower part is less hard, is conglomerate only in some layers and has a rusty color on the weathered surface. The dip is almost south-east at fifty-five degrees.

Ten feet of brownish sandstone are exposed at fifteen feet above this conglomerate, but no further exposure occurs in a horizontal space of about 1175 feet. Fragments with Chemung fossils are abundant in the first 500 feet of this interval, but beyond that they become less plenty and soon disappear, so that proof of Chemung is not likely to abound in the upper half of this interval.

The bottom of the undoubted Vespertine, the "Quarry rock" of Lesley

is exposed at the end of this interval. The exposure shows only five feet, but the fragments indicate a thickness of fully thirty feet. The rock is light gray, some parts are very hard and in thick layers, but others are in thin layers; the dip is nearly fifty degrees.

This rock is succeeded by shales ill-exposed and extending nearly 400 feet to the eighth mile post. The exposure is so poor that the dip could not be ascertained, but it may be taken as averaging not far from thirty-five degrees. Here belong the coal beds, to which reference has been made, and one of them is mined on the opposite side of the river.

From the eighth mile post for 1175 feet, everything is practically concealed. Clearly enough the interval is occupied by gray to bluish sandstones and shales, but there is no exhibition good enough to tell the rate of dip. An uncertain measurement almost midway in the interval made the rate not far from twenty-five degrees. As the next exposure shows a dip of only fifteen degrees, the dip in this concealed interval may be averaged at twenty degrees.

This is succeeded by a reddish or bluish sandstone, forty feet thick, which is well shown in a cliff on the hillside but does not appear in any of the railroad cuts. The dip is fifteen degrees.

No further exposure occurs for 200 feet, beyond which comes a sandstone with dip of ten degrees. This is shown as a cliff, but it was not seen in the cuts; it continues for a horizontal distance of 600 feet. The color varies from gray to rusty brown and the rock is fine-grained but irregular in bedding.

This is succeeded by a concealed interval of 375 feet, in which the dip is twelve degrees; beyond it one comes to red sandy shale extending 300 feet with dip of twelve degrees. Upon this rests a red to gray, irregularly bedded sandstone continuing for 200 feet, also with dip of twelve degrees. After a concealed space of ninety feet, sandstone, gray to red, is reached, which, with dip of fourteen degrees, extends for 300 feet along the track. It contains many thin beds of red shale and some insignificant beds, or rather streaks, of impure limestone or possibly only calcareous sandstone. Above this are alternations of red sandstone and red shale, with dip of fifteen degrees and continuing for 2200 feet to Back creek just beyond Tyler's coal switch. Next comes the geodal limestone, to which reference has been made so frequently and which belongs at the base of the Knox limestone. Evidently the fault of Walker mountain has been crossed; so the succession may be summarized. It is as follows:

Lower Silurian.

Limestone in bank of Back creek.....25′

The Walker Mountain fault.

Lower Carboniferous.

1. Red sandstones and shales.....570′
2. Sandstone, red to gray with some shale..... 73′
3. Concealed..... 23′

4. Sandstone, red to gray..... 42′
5. Red shales..... 63′
6. Concealed..... 78′
7. Sandstone.....105′
8. Concealed..... 42′
9. Sandstone, reddish brown to bluish..... 40′
10. Shales and sandstones.....400′
11. Shales with coal beds.....230′
12. "Quarry" sandstone..... 30′

Devonian.

1. Concealed.....900′
2. Sandstone..... 10′
3. Concealed..... 15′
4. Conglomerate..... 30′
5. Sandstones, flaggy, not well shown.....160′

The Walker Mountain fault passes very near the mouth of Back creek and is crossed by that stream at a little way west from the railroad. The exposure of the shales is practically continuous to the creek, but there were seen none of the yellow shales observed on the Dublin and Pearisburg pike. The line of fault is therefore drawn directly under the limestone of the Knox group.

Southward from Back creek for nearly a mile, the whole region near the railway is covered with a thick deposit of terrace debris, and the only exposure is in a cut at about 1000 feet from the end of the Back creek trestle, where a veined, somewhat brecciated limestone is shown associated with light drab shales, all belonging to the lower part of the Knox limestone. The next exposure is in a stream at, say, 600 feet south from Belspring station, where limestones and shales are shown. Similar beds are exposed on the railroad at about 300 feet further, where the shales, or rather shaly limestones, weather light yellow or grayish white. The limestone is drab to blue, is somewhat silicious, is veined with white spar and is more or less brecciated. The dip is south-eastward at about eighteen degrees. But the dip quickly becomes flexuous and these shales and limestones remain in sight to the fifth mile post. The irregular dip continues for half a mile further, but thence for a mile or two, to within three miles and a half of New River station, the more prevalent dip is south-eastward, so that the massive limestones with large nodules of chert are brought down. These thicker beds are separated by impure shaly limestones which weather into clays, usually yellowish red.

The dip becomes north-westward at three miles and a half from New River station, and this direction is kept for probably a mile along the road, which follows the strike for much of the distance. In the deep cuts about two miles and a half from New River station, the beds are in great disorder and consist of the shaly limestones which the reversed dip has brought to the surface again. Thence no exposure was found until the first mile

post was reached, where somewhat higher beds are shown in very confused stratification. From this place to the main line of the Norfork and Western railroad at New River bridge, the thick bedded limestones of the Knox group are bent and folded to a degree, which one would think hardly possible in rock of that character, yet so far as could be ascertained no fractures exist.

Returning to the New River gap through Walker mountain and crossing the river so as to take the road leading across Price mountain to Christiansburg, one comes to the Vespertine as the road rises to the river hill. But exposures quickly become indefinite and little is shown until beyond Price's fork in the road, about five miles west from Blacksburg. The only exposures in this interval of four or five miles are of drab shales such as were seen in the cut south from Belspring station on the New River branch of the Norfolk and Western railroad. The whole area for several miles from the river is covered with the terrace deposit, which is very deep. The Knox limestones are shown on the Blacksburg road, as well as to a short distance south from it, dipping southwardly; but a synclinal is crossed between that road and the northerly fault of Price's mountain, so that the limestones, where last seen, dip away from the fault.

Red shales of the Lower Carboniferous, such as those seen on New river, are shown on the flank of Price mountain, and are underlaid by the coal-bearing Vespertine. The coal beds are mined along a fork of Strouble's creek on the northerly side of the Price Mountain anticlinal. Several abandoned openings were seen on the Bruce property, one of which showed

1. Sandstone.....not measured.
2. Clay.....0′ 5″
3. Coal.....0′ 10″
4. Slaty coal.....1′ to 0′ 10″
5. Coal seen.....2′ 6″

The dip is northward at thirty degrees; the coal has been crushed badly but not so badly as in the mines of Little Walker or Brush mountain. The bed is mined by Linkous and Kipp at somewhat more than half a mile further west, where, according to Mr. Linkous, the lower part of the bed is

5. Coal.....2′ 6″ to 2′ 10″
6. Coal.....1′ 3″
7. Coal.....1′ 6″

No. 6 is soft and is used as the "bearing-in," but the others are very hard. The coal has been crushed to but a very slight extent in comparison with that on the other mountains. It bears much resemblance to cannel. It is mined extensively and is wagoned to Bang's station, whence it is shipped to neighboring stations.

The rocks alongside of the road dip at fifty-five degrees as the crest of the anticlinal is approached; but on the other side near Mr. Church's mine, the dip in the southerly direction is barely twenty degrees. Thence

nothing was seen aside from the shales and sandstones until the Blacksburg and Christiansburg road was reached, on which the southerly fault of Price's mountain was crossed at a little way north from Mr. Stevens's house, where Umbral shales and Knox limestones are in contact.

Directly north from Mr. Stevens's house, the road from the coal mines unites with that leading northward to Blacksburg and Newport. Exposures are very indefinite on this road as it crosses Price's mountain, though the Lower Carboniferous shales are shown in several shallow cuts. No coal blossoms were seen along the road and no coal is mined near it.

The Knox limestones are reached at somewhat more than two miles south from Blacksburg, but exposures on this old erosion plane are few and widely separated, so that nothing can be told respecting the character of the rocks.

The place of the Walker Mountain fault is about half a mile south from Tom's creek, where Umbral shales are thrown over to almost vertical dip, while the Knox limestones are shown within a few rods with much gentler dip. Coal is mined at several places on Tom's creek both above and below this road. The dip at a pit immediately south from the creek is twenty-five degrees toward the south-east. The bed is thin, being reported as follows:

Coal	1′
Clay	0′ 6″
Coal	1′ 6″

but the bed is thicker at other pits and, at some, it has three feet of workable coal. The crush has been severe and the coal of the Tom's creek mines is so loosely laminated that the laminæ are easily separated by the fingers.

The dip becomes gentler as the road ascends Brush or Little Walker mountain. Sandstones with dip of ten to twelve degrees make the roadbed for a long distance and form spurs extending southward from the mountain. The passage to the Chemung is through these yellowish sandstones, which appear to be thicker than on New river. The upper beds of the Chemung are not shown near the road; fragments of the upper conglomerate are numerous, but the rock was not seen in place. It however forms the crest of Brush mountain and Chemung fossils are numerous at several exposures on the northerly slope as the road descends to "Poverty flats," the "Poor valley" between the Walker mountains. The conditions in this valley, digged out of Chemung, Hamilton and Clinton shales, differ in no way from those in the "Poor valleys" already described. Exposures show nothing but shales.

The Clinton ore was mined here many years ago for the furnace at Newport, in Giles county, but nothing can be learned now respecting either its quantity or quality. Medina forms the southerly slope of Gap or Big Walker mountain and on the summit is dipping south-eastwardly at sixty degrees.

The Triassic Mammals, Dromatherium and Microconodon.

By Henry F. Osborn, Sc. D.

(*Read before the American Philosophical Society, April 15, 1887.*)

The mammalian jaws discovered by Professor Emmons in the Upper Triassic beds of North Carolina, and ascribed to a single genus, *Dromatherium*, were recently examined by the writer and found to belong to separate genera. The type mandible of *Dromatherium* is preserved in the Williams College Museum, and differ widely from the mandible preserved in the Museum of the Philadelphia Academy. These differences have already been pointed out,* but require to be more fully stated, as both Professors Marsh and Cope have expressed doubts as to the distinct separation of these genera. The accompanying lithographic figures also bring out the characteristic features of these mandibles much more fully than in the pen drawings which accompanied the earlier description.

In many respects these genera agree with each other, and stand separate from the Jurassic mammals of both England and America. There is, first, a considerable diastema behind the canine, a very rare feature in the division of Mesozoic mammals to which these genera belong, although always present in the division to which *Plagianlax* and its allies belong, viz., the sub-order *Multituberculata* Cope.

Dromatherium has three premolars and seven molars, but the number in *Microconodon* is quite uncertain, as only four of the series are preserved. The molars agree in one particular, which separates them widely from other Mesozoic genera, viz., in the imperfect division of the fangs. This division is indicated merely by a depression at the base of the crown, as in the genus *Dimetrodon*, among the Theromorph reptiles.

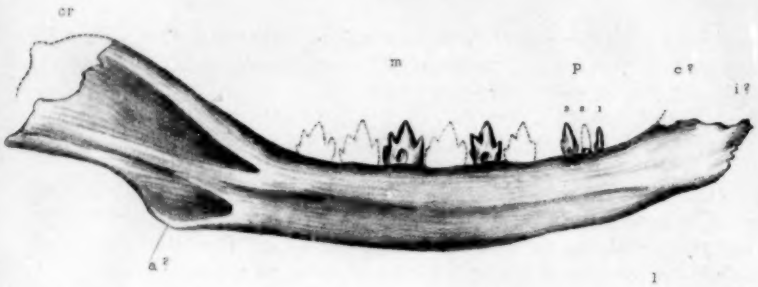
In all other respects these mandibular rami differ widely. The *Microconodon* ramus is two-thirds the length of that of *Dromatherium*; it is flattened and slender, with a nearly straight lower border beneath the molar alveoli, and a characteristic depression of the border which possibly represents the angle of the jaw as in Prof. Owen's genus *Peramus*. The coronoid process is low and the vertical diameter of the jaw at this point is very narrow. This ramus offers a great contrast to that of *Dromatherium*, which is very stout and convex with a thick lower border, projecting widely from the matrix, an elevated coronoid process and has the curvature of the lower border unbroken by any downward projection. If these differences may be given merely a specific value, and attributed in part to the fact that the *Microconodon* jaw is seen upon the outer surface, and that of *Dromatherium* upon the inner surface, let us compare closely the teeth in the two genera. Unfortunately the canine and incisors of the

* Proceedings of the Academy of Natural Sciences of Philadelphia, 1886. p. 359. I find upon a second examination of Prof. Emmons' original figure, that I did unintentionally criticise it too severely in the former article, p. 359. While far from accurate the figure is not so misleading as I at first supposed.

Microconodon ramus are wanting. We first observe that the premolars of *Dromatherium* are styloid and procumbent; if erect they would rise above the level of the molars; they have no trace of a cingulum. In the other genus the premolars are subconical and, although erect, they do not reach the level of the molar tips; they show a faint posterior cingulum, and the third premolar has the same evidence of a division of the fang which is seen in the molars, while in *Dromatherium* there is no trace of such a depression, but a distinct groove on the postero-internal face of the tooth reaching nearly to the summit. The molars of *Dromatherium* are narrow and lofty; the general pattern of the crown consists of a single main cone with a high anterior and lower posterior accessory cusp upon its slopes; but these cusps are very irregular in disposition. For example, in the second molar there are two anterior cusps; in the third molar the posterior cusp is nearly as large as the main cusp; in the fifth molar there is a trace of a postero-external cusp; in the last molar both the anterior and posterior cusps are distinctly bifid at the tip. In *Microconodon*, on the other hand, the molars are comparatively low and broad, with a low anterior and higher posterior accessory cusp; these cusps are regular and very prominent; there is also a well-marked posterior cingulum, which cannot be distinguished in the corresponding molars of the other genus.

Although the two posterior molars are wanting in *Microconodon*, the rise of the coronoid probably marks the position of the last molar; taking this estimate of the posterior point of the molar-premolar series and comparing it with the length of the series in *Dromatherium*, we find that while the ramus of one genus is only two-thirds the length of the other, the total space occupied by the molar-premolar series is very nearly the same. Estimated in another way, the molar-premolar series of *Microconodon* is a little less than one-half the entire length of the jaw ($\frac{6}{13}$), while that of the other genus is exactly one-third the length of the jaw. This discrepancy is due to the difference in the proportions of the molars; in one genus they are low and broad at the base, in the other they are unusually high and compressed.

It is difficult at present to assign any systematic position to either of these genera. *Dromatherium* is entirely unlike any known mammal, fossil or recent. The form of the molars is extremely primitive both in respect to the incomplete separation of the fangs and the remarkable variations in the number and size of the accessory molar cusps. In fact the molars appear to be in what may be called an experimental stage of structure. The accessory cusps are sometimes large and distinct, as in the third true molar; sometimes minute like needle points, as in the second molar. The incomplete separation of the fangs is a reptilian character, which correlated with the styloid premolars and recurved canine-incisor series, place *Dromatherium* very remote from any of the known Mesozoic mammals. *Microconodon*, on the other hand, is a somewhat more "recent" type, the premolars have the trace of a low posterior heel, and the molars



1

1a

2b

1b

2a

2

T. SINCLAIR & SON, LITH. PHILA.

1. MICROCONODON. 2. DROMATHERIUM.

have that regular tricuspid division of the crown which is first observed in the genus *Amphilestes* of the English Lower Jurassic and characterizes a large number of the Jurassic mammals.

EXPLANATION OF PLATE.

Figure 1. *Microconodon tenuirostris.* The outer surface of the right mandibular ramus, enlarged. The two premolars preserved are the first and third, with the fang of the second between. The space behind the third was occupied either by a fourth premolar and the first molar, or by the first and second molars. The molars preserved are, therefore, either the second and fourth, or the third and fifth. The dotted outlines are purely conjectural.

1*a*. The same, natural size.

1*b*. The fourth or fifth molar, much enlarged.

Figure 2. *Dromatherium sylvestre.* The inner surface of the left mandibular ramus, enlarged.

2*a*. The same, natural size.

2*b*. The second molar, much enlarged.

ABBREVIATIONS.

a. Angle; *c*. canine; *cn*. condyle; *cr*. coronoid; *i*. incisors; *mg*. mylohyoid groove; *m*. molars; *p*. premolars.

The Relation of Aerolites to Shooting Stars.

By Professor Daniel Kirkwood.

(*Read before the American Philosophical Society, April 15, 1887.*)

The writer more than twenty years since gave reasons for believing that shooting stars, fire balls and meteoric stones move together in the same orbits.* The facts then collected were deemed sufficient to sustain the theory advanced, or at least to give it a high degree of probability. This view has been rejected, however, by several eminent astronomers, and especially by the present Astronomer Royal for Ireland, the distinguished author of "The Story of the Heavens." He remarks: "It is a noticeable circumstance that the great meteoric showers seem never yet to have succeeded in projecting a missile which has reached the earth's surface.

* Meteoric Astr., Chap. v.

Out of the myriads of Leonids, of Perseids, or of Andromedes, not one particle has ever been seized and identified. Those bodies which do fall from the sky to the earth, and which we call meteorites, never come from the great showers, so far as we know. They seem indeed to be phenomena of quite a different character to the periodic meteors" (Story of the Heavens, p. 349).

In pointing out the coincidence in the epochs of shooting stars and meteoric stones,* the present writer neglected to assign an obvious reason for the fact that star showers are so seldom observed at the same time with the fall of aerolites: a majority of the latter have been seen in the day time, when ordinary shooting stars would be invisible. At night, however, the phenomena have more than once occurred at exactly the same time. The writer called special attention to one of these epochs as long since as 1881.† In describing the shower of April meteors as it occurred in the year 1094, the historian says: "At this period so many stars fell from heaven that they could not be counted. In France the inhabitants were amazed to see one of them of great size, fall to the earth, and they poured water on the spot, when to their exceeding astonishment, smoke issued from the ground with a hissing noise."‡ A few other examples are given below:

(1.) During the meteoric display which continued through three consecutive nights in the latter part of October, A. D. 585, a globe of fire, sparkling, and producing a great noise, fell upon the earth.§

(2.) A simultaneous fall of aerolites and shooting stars is indicated by the phenomena of 1029, as described in the catalogues of Herrick and Quetelet.

(3.) But without quoting other records which imply the existence of aerolites and ordinary meteoric matter in the same streams or clusters, it is sufficient to refer to the recent and very decisive phenomena of November 27, 1885.‖ During the periodic star shower from the fragments of Biela's comet a mass of meteoric iron weighing about ten pounds was seen to fall near Mazapil, Mexico, in lat. 24° 35′ N., long. 101° 56′ 45″ W. from Greenwich. The evidence afforded by the phenomena of 1094 and 1885, apart from the other cases cited, renders the coëxistence of large and small masses in the same meteor streams almost infinitely probable.

* Metr. Astr., pp. 58–64.

† Science, Feb. 5, 1881, p. 59.

‡ Am. Journ. of Sci., Jan., 1841, p. 356.

§ Quetelet's Physique du Globe, p. 291.

‖ Am. Journ. Sci., March, 1887, p. 221.

Organic Variation Indefinite not Definite in Direction—an Outcome of Environment.

By Prof. E. W. Claypole, B. A., B. Sc. (Lond.), F. G. S., &c. Akron, O.

(Read before the American Philosophical Society, April 1, 1887.)

I.

Introduction.

Two remarkable utterances have recently appeared from the pens of two of the most distinguished biologists of the day in defense of a theory of evolution radically unsound and differing, as the writer thinks, from that which is held by the majority of evolutionists. The eminence of the names of these authors is sufficient reason to justify a consideration of the view they have advocated. It cannot be supposed that Prof. Asa Gray, of Cambridge, Mass., and Dr. W. B. Carpenter,* of London, would put forward statements all the aspects of which they had not fully considered, and all the legitimate conclusions from which they were not prepared to maintain. Yet both these distinguished writers have enunciated a view of evolution fraught with momentous consequences to biology. So momentous indeed are they that they exclude (if the views in question are well founded) a very large part of the field of investigation now before the biologist from the lawful domain of natural science and relegate it to another department of enquiry.

The nature and direction of organic variation are subjects which have become prominent during the intellectual ferment excited by the publication of the "Origin of Species." As a fact variation is admitted by all evolutionists. It is indeed the cardinal fact on which all theories of evolution do and must depend. And both the writers above mentioned alike admit its reality and its importance. Both allow or tacitly assume that there runs through all organic nature a capability of varying from generation to generation—that under the superficial and obvious resemblance existing between parent and offspring there lie deeper and less easily discerned distinctions which differentiate the one from the other and accumulate in certain directions from age to age. This capacity, manifesting itself in the fact of variation, when encouraged or repressed by the action of natural or other selection has—so Darwin maintained—resulted in the extinction of old and the production of new species.

But while agreeing thus far with most evolutionists the two writers in question express views on variation that are remarkable in the following respect. Instead of proceeding on the ground that variation occurs, or

* These pages were written before science had been deprived of the services of this veteran laborer and leader in biological research by the deplorable accident which caused his death.

may occur, indiscriminately in any direction as lines radiate from a centre, both Prof. Gray and Dr. Carpenter assume or maintain that it takes place only along certain definite lines. Yet further, in their view the changes thus produced in an organism are uniformly of a beneficial kind.

That I may not be subject to the charge of misrepresentation I quote the following extracts from the writers referred to.

In a paper entitled "On an Abyssal Type of the genus *Orbitolites*; a Study in the Theory of Descent," published in the Philosophical Transactions, for 1883, Dr. Carpenter remarks, after detailing the variation exhibited by the forms of *Orbitolites*, "that no exercise of natural selection could produce the successive changes presented in the evolutionary history of the group." "And," he adds, "as all these earlier forms still flourish under conditions which, so far as can be ascertained, are precisely the same, there is no ground to believe that any one of them is better fitted to survive than another." "To me therefore it appears that the doctrine of natural selection can give no account of either the origin or the perpetuation of those several types of foraminiferal structure which form the ascending series that culminates in *Orbitolites complanatus*." "On the other hand there seems traceable through the series a plan so obvious and definite as to exclude the notion of "casual or aimless variation." "Everything in their history shows a well-marked progressive tendency along a definite line towards a highly specialized type of structure in the calcareous fabric."

The significance of these remarks is unmistakable. The writer is evidently maintaining that alongside of the capacity for variation there acts some power guiding the ensuing variation along a definite course to a definite end.

One expression in the above passage calls for a passing remark. In saying that the doctrine of natural selection can give no account of the *origin* of these types Dr. Carpenter appears to have overlooked the fact that no evolutionist attributes the *origin* of varietal or specific forms to this source. Their origin must be sought in variation. Natural selection is only the means of preserving and perpetuating or of destroying and eliminating them. This remark would perhaps be impertinent were it not that other expressions in the same essay also apparently ignore the part played by variation in every accepted theory of evolution. For example, we read, "Those who find in natural selection or the survival of the fittest an all-sufficient explanation of the origin of species seem to have forgotten that before natural selection can operate there must be a range of varietal forms to select from." "No exercise of natural selection could *produce* the successive changes presented in the evolutionary history of the typical *Orbitolites* from *Cornospira* to *Spiroloculina* thence to *Peneroplis*, to *Orbiculina*, to the simple and then to the complex forms of *Orbitolites*."

There is in this passage a singular omission of all reference to the fact

FIG. 5.—Through Sharon Springs. *a*, Garden axis; *b*, Brushy Mt.; *c*, Big Walker Mt.; *f*, Saltville fault; 3, Lower Carb.; 4, Devon.; 5, Upper Silur.; 6, Lower Silur.

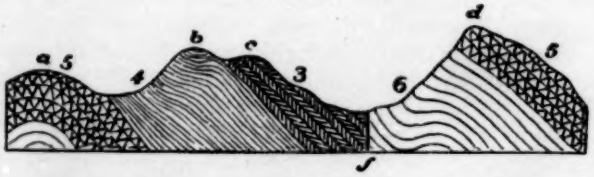


FIG. 6.—Through Seddon. *a*, Garden Mt.; *b*, Kimberling axis; *c*, Brushy Mt.; *d*, Big Walker Mt.; *f*, Saltville fault; numbers as before.

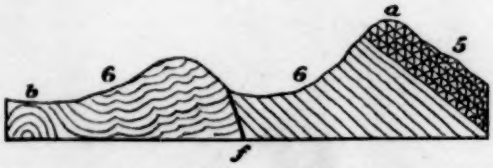


FIG. 7.—Through Newport. *a*, Big Walker Mt.; *b*, Sinking Creek axis; *f*, Saltville fault; Numbers as before.

FIG. 1.—After Lesley; Ideal cross-section showing the downthrows.

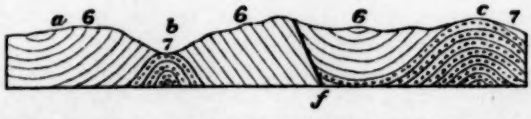
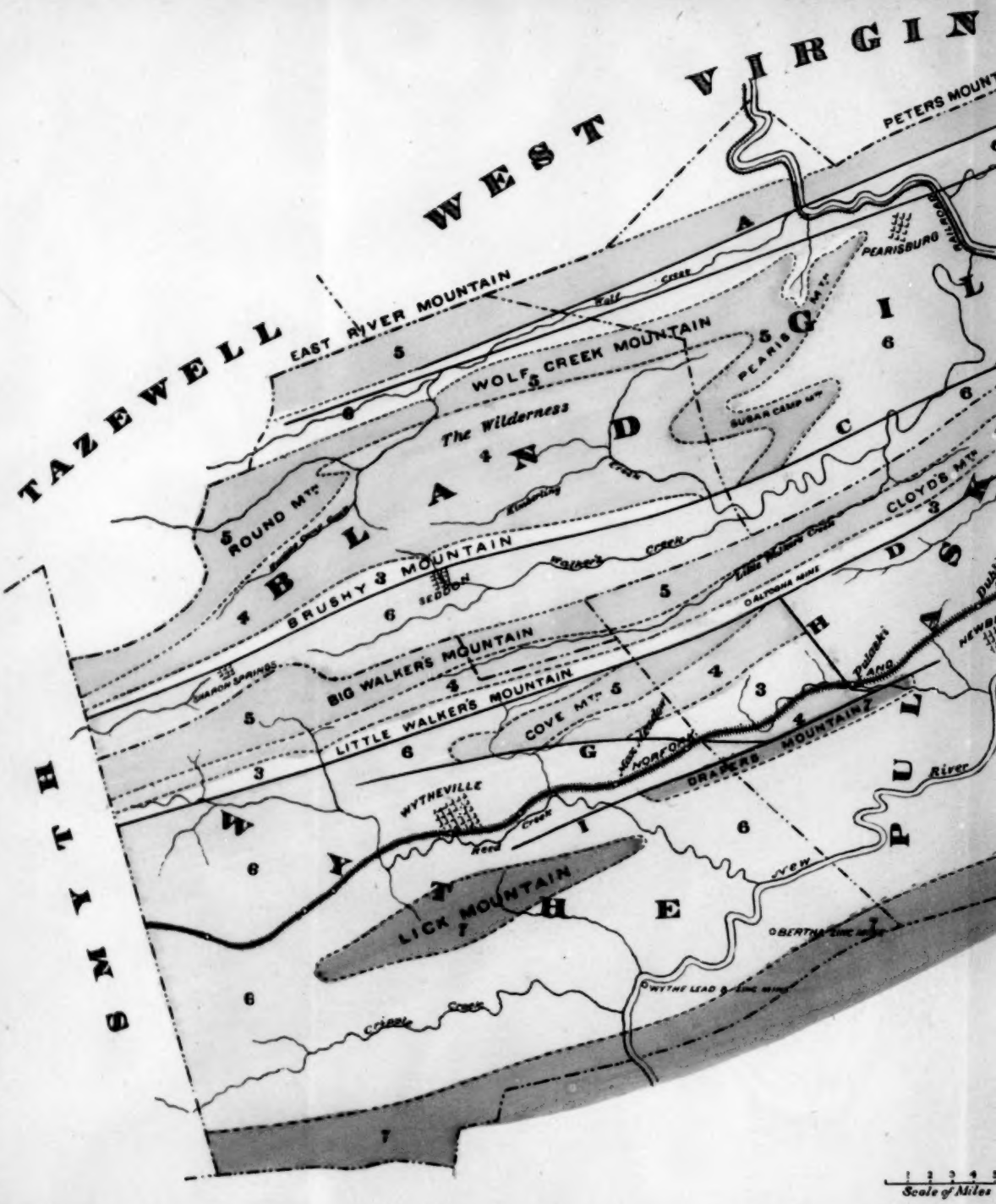
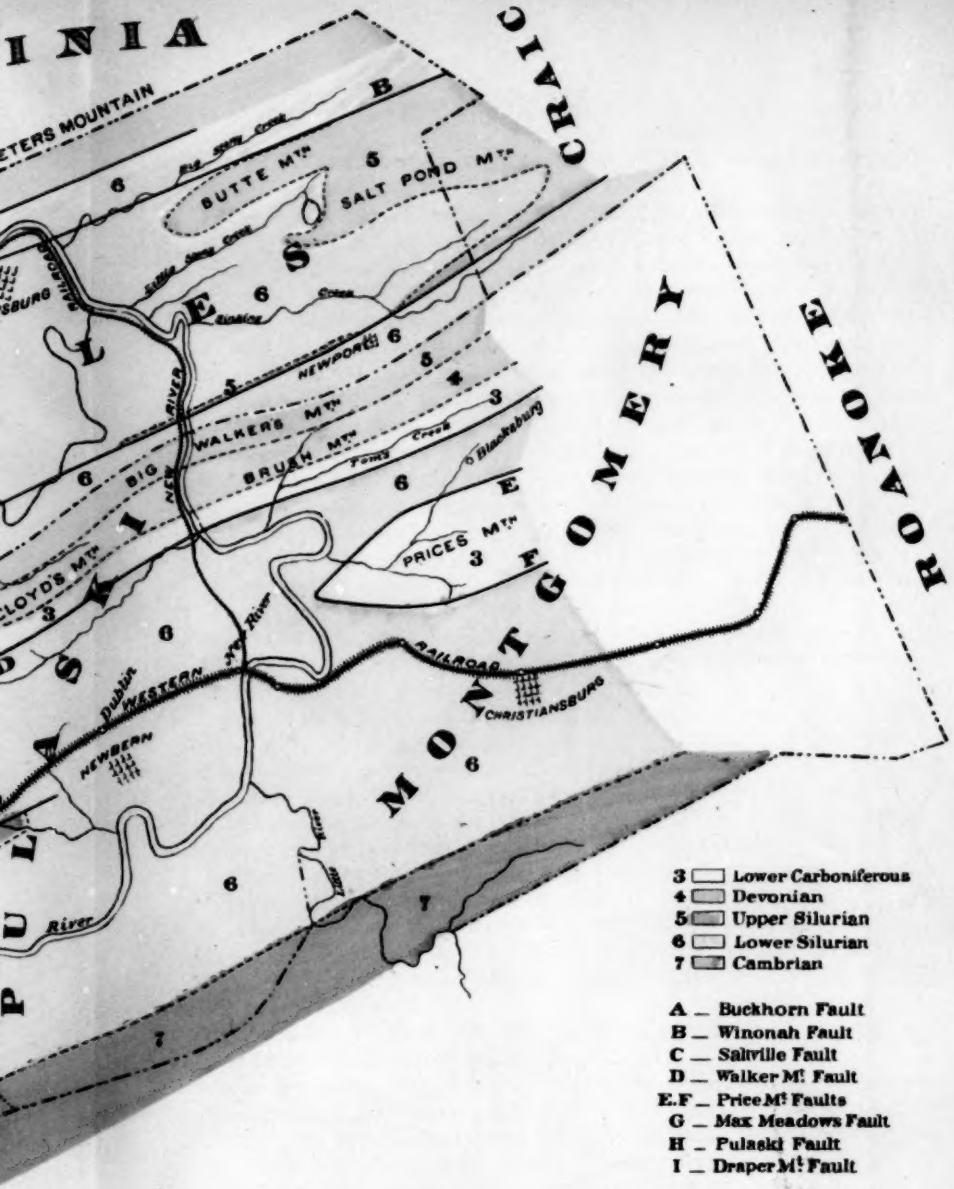


FIG. 2.—Section through Kent's Station on Norfolk and Western Railroad. *a*, Wytheville synclinal; *b*, Wytheville anticlinal; *c*, Lick Mt. anticlinal; *f*, Draper Mountain fault; 6, Lower Silurian; 7, Cambrian.

FIG. 3.—Near line between Wythe and Pulaski counties. *a*, Draper Mt.; *f*, Draper Mt. fault; *f*[1], Max Meadows fault; 3, Lower Carboniferous; 6, Lower Silurian; 7, Cambrian.

FIG. 4.—On Pulaski road. *a*, Draper Mt.; *b*, Draper Valley; *c*, Macadam road; *f*, Draper Mt. fault; 4, Devonian; 6, Lower Silurian; 7, Cambrian.


WEST VIRGIN
TAZEWELL
PEARISBURG
EAST RIVER MOUNTAIN
WOLF CREEK MOUNTAIN
The Wilderness
ROUND MTN
BRUSHY MOUNTAIN
BIG WALKER'S MOUNTAIN
LITTLE WALKER'S MOUNTAIN
COVE MTN
CLOYD'S MTN
GRADERS MOUNTAIN
LICK MOUNTAIN
WYTHEVILLE
SEDDON
SHARON SPRINGS
Walker's Creek
Reed Creek
Cripple Creek
New River
Scale of Miles



GEOLOGICAL MAP OF
GILES, BLAND & WYTHE COUNTIES
WITH PARTS OF
PULASKI & MONTGOMERY COS.,
VIRGINIA.

by J. J. Stevenson.

1886.

1 2 3 4 5
Scale of Miles

and function of variation, the existence of which no naturalist can doubt, be his explanation what it may.

The second utterance of opinion to which I have alluded is contained in a letter from Prof. Asa Gray, printed in "Nature" (Jan. 25, 1883). The letter itself is written in reply to some remarks made by Mr. G. J. Romanes in an article in the "Contemporary Review" for October, 1882. It is difficult to quote any particular passages in exemplification of the views of Prof. Gray, which are rather implied than expressed. The main point of difference between the two writers is however the denial by Mr. Romanes that "the facts of organic nature furnish evidence of design other and better than any of the facts of inorganic nature," and the maintainance by Prof. Gray that this denial rests on no good foundation. In some passages indeed the latter writer goes apparently even farther than this merely negative position and implies, if no more, that in his opinion variation has been beneficently guided by intelligence. It is difficult to extract any other meaning from the following passage: "The evidence of design may be irresistible in cases where we cannot indicate its limits. We can only infer with greater or less probability according to circumstances and especially according to relation to ends. Better evidence than that of exquisite adaptation of means to ends is seldom if ever attainable of human intention and in the nature of the case it is the only kind of evidence which is scientifically available in regard to superhuman intention. With what propriety then can it be affirmed that organic nature furnishes no other and no better evidence of underlying intelligence than inorganic nature? The evidence is certainly *other* and to our thinking *better*."

It seems impossible to attribute to the author of this passage any intention other than that already expressed; viz.: that alongside of the capacity for variation there acts some power guiding the ensuing actual variation along a definite course to a definite end.

If any doubt yet exists concerning Dr. Gray's meaning, such doubt must be altogether removed by the following extract. In a notice of Dr. Carpenter's paper in the "American Journal of Science," for April, 1884, Prof. Gray says:

"Variation has been led along certain beneficial lines like a stream along certain definite and useful lines of irrigation."

The expression "has been led" is rather indefinite, but can scarcely mean less and may mean much more than I have above attributed to its author. To assert that variation has been led along definite lines implies the coaction of some guiding power. To assert that these lines are always beneficial to the variant organism implies a postulate of vast magnitude and one whose admission is infinitely difficult in face of the phenomena of organic nature.

II.

Definition of Terms.

The purpose of this paper is in the first place to examine so much of the evidence of nature on this point as shall be sufficient to show that the

theory of evolution favored by the writers above quoted is not in harmony with the facts, and in the second place to prove that, taken as a whole, the phenomena of nature in the organic world are much more easily explained by the principle of indefinite variation.*

To prevent ambiguity and perhaps misunderstanding it will be well to define at the outset the principal terms that will be employed in this paper.

"Variation" will be here taken to mean all deviations of every kind and degree from perfect resemblance to the immediate parents of the organism whether animal or vegetable. This is the widest signification which it is possible to give and with no other can any useful conclusion be reached. Any limitation can only result in invalidating the argument because it would confine the discussion to a special part of the subject indicated by such limitation. The universal signification to be here employed is also the only fair interpretation that can be accepted by all Evolutionists.

The organism in which such Variation is supposed possible will be called a "Variable." The term is borrowed from mathematics and will be understood to mean an animal or plant possessing the capability of varying whether that capability be latent or active. At any one given instant this power may be always considered latent, time being a necessary element in actual variation.

When from any cause this possible variation has become actual and the organism shows progressive resulting changes, this organism may be called a "Variant." And again when a series of changes is complete or when any particular phase is intended the organism in that stage may be called a "Variate." Thus the term "Variable" will indicate that change is possible; "Variant," that such change is in process, and "Variate," that it is complete, at least for the time, in any given organism.

The term "beneficial" will be employed to characterize any change that conduces to the longer life of the variant organism; this being, for the most part, and other things being equal, the greatest benefit that can accrue to it. I do not deny that there are exceptional cases in which other inherited or acquired advantages may outweigh even this usually supreme one. But almost always a long life may be considered the most conducive to the continuance of the species as it indicates vigor in the individual and increases the chances of multiplication.

The expression "Tendency to Variation," sometimes employed by writers on this subject, either commits an author to the views here opposed (for such tendency must have a cause) or it is meaningless. When variation occurs it must have been antecedently possible. But its occurrence is our only proof of this possibility. Of any "tendency to variation" inherent in the organism we have no proof whatever. For all that we

*The possible assertion that variation is always beneficial in consequence of some cause underlying the constitution of the organic and inorganic worlds and their relation to one another will not be here considered. No writer has, so far as I am aware, ever distinctly enounced it and moreover it will be excluded if, as I hope, I shall succeed in showing that as a fact variation is not always beneficial.

know to the contrary an organism is capable of existing unvaried for any length of time, through generation after generation, without showing the least tendency toward any other form. As well might the mechanician or the astronomer speak of a "tendency to motion" in the heavenly bodies because he sees them all in a state of active movement. For anything that he knows to the contrary all the matter in the Universe may be capable of lying at rest for countless ages. Matter itself has no tendency to motion or to rest. It is absolutely a creature of conditions and of circumstances. So we have reason to believe that organisms have no tendency to variation or to invariance. Changes if they occur, or their absence if they do not, are simply accidents of the environment. The astronomer sees all matter in motion and comes almost instinctively to the belief that the two are inseparable. The biologist sees every organism varying and grows unconsciously into the opinion that variation is a necessary concomitant of life. Both are equally unphilosophical. Absolute rest may be almost inconceivable to the physicist and absolute invariance to the naturalist. Yet both so far as we can know, are thinkable and possible, and both may form a part of the actual scheme of Nature. We see no ground for the expression "tendency to variation."

III.

Variation not Always Beneficial.

In the consideration of this part of the subject it will be manifestly impossible within due limits to even notice any large portion of the facts that bear more or less directly on the question. No attempt will therefore be made to take a wide range. Nor is this necessary for the argument. If sufficient proofs can be adduced to show that in some cases the actual variation is prejudicial to the variant the purpose will be served. Yea, more, in logical strictness if a single such case can be established the advocacy of definite variation in a uniformly beneficial direction becomes futile. For unless such beneficial variation be absolutely constant and unfailing no object can be attained by maintaining its occurrence in any single instance.

I propose therefore to limit myself to the presentation of a few of the more conspicuous instances of prejudicial variation, of which some one or more must during a lifetime fall within the cognizance of all who take any interest in the study of Nature.

I may here remark in passing that of the two authors quoted at the outset, Prof. Gray does not give a single instance in support of the proposition which he is maintaining and that the only one under discussion by Dr. Carpenter is drawn from the lowest class and one of the most obscure in the animal kingdom—the Rhizopods—among the Protozoa.

1. *Variation in color.*—Among the many variations in color constantly occurring among animals is the production of a white descendant from colored ancestors.

Every naturalist knows that among wild land animals, with some few exceptions, this color is exceedingly rare. The cause of this rarity is obvious. In a green world a white individual is very conspicuous. Such an animal has much less chance of escaping from its enemies if pursued, or of capturing its prey if a pursuer, than one whose color is more in harmony with its surroundings. Hence its prospects of living and of leaving offspring are proportionally reduced. And in places where green is not the prevailing color, we find the wild animals dressed in harmony with their surroundings. In the Polar regions and in winter the fur-bearing inhabitants are clad in white. No other livery would give them so good a chance of life. In dry and sandy deserts the prevailing color of the fur of the residents is nearly the same as that of the sand. Nevertheless in the parts of the world that are clad in green, white individuals are frequently produced. And we can hardly doubt that similar exceptions to the prevalent color occur elsewhere. Thus we find white deer, white mice, white blackbirds and white wild horses. But their extreme rarity shows that there is some check to their multiplication. And in asserting that this check is nothing more than early destruction in consequence of their conspicuousness I am not going beyond what has often been observed in cases falling within our notice. "On some parts of the continent," says Darwin, "persons are warned not to keep white pigeons" on account of their liability to destruction by hawks. (Origin of Species, 1860, p. 84.)

And when to these disadvantages we add those of deafness, of epilepsy and of other diseases which often accompany the white color in animals, cats for example, we find an accumulating variation which cannot fail of being deeply prejudicial to the variant.* Darwin says, "Cats with blue eyes are almost invariably deaf." He has collected a great number of cases showing the disadvantages to which animals are liable whose hair is partially or altogether white.†

Another instance is afforded by some pet rats kept by a relative of the author's, which were with one exception wholly white. They all recently became troubled with bronchitis or some similar complaint, and the sound of their breathing was so unpleasant that they were destroyed except one. The sole survivor was the rat that was not entirely white. This one, though sharing in the disease, was much less severely affected.

The case of albinoes may fairly be cited here. In this form of variates not only is the increased color-risk a source of danger, but the imperfect sight so frequently accompanying the whiteness is almost equally prejudicial.

In regard to the vegetable kingdom similar facts may be given. Every gardener is aware that the white seedlings that so frequently come up, in a field of maize for instance, usually die down and yield no seed. Here, as in the case of albinoes among animals, the radical cause of prejudicial

* See examples of this published in various numbers of Nature, 1884.
† See "Animals and Plants under Domestication," Vol. i, p. 330.

results seems to be the want of the usual vigor, probably in consequence of arrested development or of imperfect ante-natal nutrition—two of the most fruitful sources of variation.

2. *Variation in strength.*—It comes within the observation of all that among animals great difference of bodily strength exists. This is easily noticed in those that are reared for draught. Though less conspicuous the fact is equally true of the savage species. Now this deficiency of power is prejudicial to the variate. The load which one horse can draw with ease is a severe tax on another. A battle between two wild beasts is decided, other things being equal, to the injury and often the death of the weaker. Indeed the prejudicial effect ensuing upon bodily weakness is so evident that long proof is superfluous.

Nor is the deficiency of mental power any less prejudicial. Every one accustomed to observe animals must have noted great difference in their intelligence. Among domesticated species one individual shows mental power fully entitled to the name of reason, while another, perhaps of the same brood, manifests so little that education is impossible. A well-known horse-trainer once told me that though he never failed to train a horse when he took him in hand, yet there were but few that he could train at all, and that he could, in a very short time, pick out and reject the many with which success would be impossible. Some rats are so cunning that to catch them requires all the craft and skill of the householder. Others are so silly that they walk into the trap the first time it is set, and are killed to their great prejudice. The sagacity of bears in avoiding the snare is sometimes wonderful, compelling the belief that they have mastered its construction and found out how to take the bait and yet avoid the danger. Others show no subtlety of this kind, and are caught and killed with ease. Such tales may be found in any work on the habits of animals, and need not be repeated here. But enough has been said to show that the range of variation of the mental faculties of animals is great, and that while the higher degrees confer much advantage on their possessors, the lower are so far inferior as to be seriously prejudicial.

Though pertinent to the argument, it is scarcely worth the time to point out the frequent occurrence of similar prejudicial variation in the human species where the range of the mental faculties is from idiocy upward. In our present state of civilization this disadvantage is partially and temporarily neutralized by the humane sentiment prevailing in society which counteracts the laws of natural selection as they operate among other animals. Yet all such deficiency of power is seriously and often fatally prejudicial

3. *Variation in the senses.*—Whatever prejudicial effect ensues from deficiency of bodily or mental strength is aggravated when this deficiency takes the form of the absence of one or more of the senses. Yet animals are not infrequently born blind or deaf, and the probable reason why such cases are seldom seen is that the absence is so prejudicial as to be soon fatal.

In the consideration of this subject we must bear in mind that to obtain evidence from wild animals is difficult, because they are not under our supervision. Hence it is necessary in most instances to quote facts from animals kept in domestication. But abundance of cases have been recorded to show that similar prejudicial variation occurs among animals in the wild state.

4. *Variation in form.*—Under this head I may quote the well-known case of the Ancon or otter sheep of Mass., "which originated in 1791 with a single specimen having short crooked legs and a long back like a turnspit dog." This change in a natural state would have been extremely prejudicial to so active an animal. But under human control the very defect was, for a time, a convenience to the farmer, who found that these sheep could not leap over his fences. Hence he preserved and bred them. But the Merino superseded the Ancon, and without the preserving care of man the latter soon disappeared, as it would have done much earlier in a state of nature.

The once well-known turnspit dog supplies another case in point.

A friend of the writer once had a kitten which was born without any hind legs— a defect which had occurred in several litters dropped by the same cat. It lived for some years to my knowledge, and may be living still. When I last saw it it was nearly or quite full grown. Its difficulty of motion was great. Yet I have seen it get up on a chair, and when it walked it threw up its hind quarters and moved with a series of jumps, much as a boy moves when walking on his hands with his feet in the air. Without the care of man so defective an animal must soon have starved for want of locomotive power.

From the above instances the transition is slight to that of monsters. Indeed the line between these and malformation so great as that last mentioned is not easily drawn. Nor do I care to insist on the distinction. The only obvious difference between them lies in the transmission or arrest of the defect. In most cases malformation so serious necessarily ends with the individual.

Some may feel unwilling to admit the pertinence of monsters to the present argument. But they cannot logically be excluded. They are only the extreme cases in which the variation is so prejudicial that life is usually short and transmission impossible. No department of either the animal or the vegetable kingdom is free from the occasional appearance of these usually inexplicable forms. Five-legged calves, sheep with two tails, two-headed fowls and other such cases of malformation are often announced. And after making all due allowance for mere external abnormality there remain enough instances certified by anatomical demonstration to show that the birth of such monsters is by no means rare.*

"The Museum of Michigan University contains a double-headed milk

*Abundant evidence that the human species is not less liable than others to this kind of variation may be seen on the shelves of almost any medical museum and especially on those of the Royal College of Surgeons of London.

snake (*Ophibolus triangulus*) of which the remainder of the body appears to be perfectly normal. Another case is recorded by Prof. Wyman * of a water snake (*Tropidonotus sipedon*) with two heads and two tails, and a similar case as well as one of a five-legged frog is reported by Mr. Kingsley,† Mr. Ryder also calls attention‡ to a specimen of the pickerel frog (*Rana palustris*) with five limbs or rather an additional pair of hind limbs fused together. This leg had six toes and its digital formula might be written—5, 4, 3, 3, 4, 5.

Among insects such monstrous forms have been observed. "Numerous instances of supernumerary legs and antennæ are recorded. The antennæ are sometimes double but more commonly the legs." Asmuss has collected eight examples and in six of these the parts on one side are treble. "Newport relates that from a single coxa of *Scarites pyrachmon* on the left side two trochanters originated. The anterior supported the true prothoracic leg, while the posterior carried two legs each as well formed as the first."§

"Other deformities occur in the wings. Cases of hermaphroditism are on record in which one wing bears the colors of the male insect and the other those of the female. Sometimes the wings are aborted or deformed."

Most persons who have had much experience in the breeding of animals can recall similar instances.

At a recent meeting of the American Entomological Society a monstrosity was noted in a longicorn beetle of the genus Acmæops in which the left front leg has three tarsi. A specimen in the collection of Prof. Riley (*Isosoma tritici*) was also described in which the fore wings are represented by rudimentary pads while the hind wings are fully developed (Science, Dec. 5, 1884, p. v).

Mr. J. A. Ryder has recently recorded similar malformation among lobsters under his observation such as the absence of eyes, partial fusion of two bodies, fusion of the eyes on the median line. These changes were coincident with the stage of gastrulation.‖

In lecturing on the denizens of the aqueous kingdom, on Friday last, at the Royal Aquarium, Mr. A. Carter referred to deformities that exist among fish. In 1885 and 1886 he had examined thousands of salmon and trout fry at South Kensington, on their emerging from the ova, and found one case of deformity in every thousand, and one case of monstrosity such as twin and dual-headed fish in every four thousand.¶

Though as said above these forms are usually inexplicable, yet their dependence on the chances of outside conditions in some instances at least is indicated in the following passage taken from Darwin's Animal and Plants under Domestication (p. 279).

* Proc. of Bost. Nat. Hist. Soc., Vol. ix, p. 183.
† American Naturalist, Vol. xii, pp. 594, 751.
‡ Zoölogy of Ohio, p. 690.
§ Packard's Guide to the Study of Insects, p. 84.
‖ See American Naturalist, for 1886.
¶ Nature, Jan. 6th, 1887, page 231.

PROC. AMER. PHILOS. SOC. XXIV. 125. P. PRINTED MAY 20, 1887.

"It is known from the labors of G. St. Hilaire, and recently from those of Dareste and others, that eggs of the fowl if shaken, placed upright, perforated, covered in part with varnish produce monstrous chickens. Now these monstrosities may be said to be directly caused by such unnatural conditions, but the modification thus induced is not of a definite nature."

It is not by any means unlikely that the indefiniteness to which the great naturalist here alludes is a mere consequence of our want of knowledge of this obscure subject and not inherent in nature. The recent experiments of Warynski & Fol, as quoted in the Journal of the Royal Microscopical Society (June, 1866, p. 401), tend strongly to confirm this opinion. These zoölogists have succeeded in producing double hearts in chickens by artificial means. The mode of procedure is as follows: "The blunt edge of a scalpel is carefully and lightly drawn backwards along an embryo between twenty-four and thirty-six hours old from just behind the head without injuring any tissues. If all goes well the embryo will continue to develop normally with the exception of possessing two hearts." The authors quoted were also able to produce other abnormalities in a similar manner.

In the absence of any evidence to the contrary it is more logical to infer that all such cases owe their origin to similar causes, antenatal accidents, not yet discoverable.*

Turning now to the vegetable kingdom we find monstrous forms by no means rare. Not seldom among wild plants the botanist finds flowers in which one portion in hypertrophied to the injury or the atrophy of another or of others. When this atrophy includes the essential organs, such as the anthers or stigmas, it results in sterility and the extinction of the species along that line. Human selection has enormously increased this form of variation. Most of the double flowers of the gardener are monsters to the anatomist. The showy double corolla is obtained at the cost of more important though less conspicuous organs. To quote special cases is here needless. Abundance of them will occur to every naturalist or may be found in works on the subject.

5. *Moral variation.*—Another phase of the subject should not be passed over though any adequate discussion of it is not practicable here. Most naturalists will agree that the moral development of an organism may be prejudicial. Animals born in domestication are not seldom so ill-tempered or obstinate that little or nothing can be made of them. Horses, subject to vice, as it is termed, are sold from hand to hand, lower and lower in the labor scale, until they end by being employed as drudges in the hardest and most menial tasks which exhaust their strength and kill them off before their time. Dogs, too, are often met with which show a disposition so ferocious or uncertain that their owners are compelled to kill them from a regard to their own safety or to that of others. And the testimony of

* For some curious illustrations of another but kindred topic in this connection see a paper on the "Disadvantages of the upright position in man," by Dr. E. Clevenger, in the American Naturalist for 1884.

the tamers of wild animals proves that the same is true among them. The temper of tamed elephants, of tamed lions (so-called), and of other wild beasts indicates a difference of moral qualities quite equal to what we see in the domesticated species. The difference is often very conspicuous in members of the same litter.

The tendency to vice born in many individuals among mankind and growing with age—the inheritance from vicious ancestors—impels its possessor to acts which shorten his days and are in other ways extremely prejudicial to him. The evolutionist may assert that this result is only Nature's way of killing off those unfit to live. The philanthropist may pity them and spend time and labor and money in trying to reform them, and occasionally with success. But both evolutionist and philanthropist thereby proclaim their belief that the moral tendencies developed in these individuals are highly prejudicial and often fatal. They are, however, the outcome of environment of themselves and their ancestors. They are effects of the variability of the organism moulded by circumstances. They are variates whose variation is hostile to their civilized surroundings and leads to extinction. In other countries and among other circumstances they might yet be fairly in harmony with their conditions of life and might live. "The most inhuman monster of crime that ever was condemned by a court and executed by an officer of the law would among such tribes as those of Australia surely pass for the embodiment of all excellences and rise to an uncontested chieftainship" (Bergen: "The Development Theory," p. 178).

It is not relevant to reply that most of the cases here cited are accidents and should not be quoted in proof of the proposition. All such actual occurrences can be logically employed. Accident merely means happening out of the expected course. If accidents happen often they partially lose that character; if they prevail they lose it altogether. If such accidents as those above mentioned were advantageous to the organism they would soon be perpetuated and become the rule. All variations are accidents and their continuance and repetition are dependent on their advantage to the variant. If prejudicial they are soon eliminated and cease.

> "Treason doth never prosper; what's the reason?
> Why, if it prosper none dare call it treason."

Variation is treason to the original organism. If it can sustain itself it becomes the new organism and supersedes the old one. If not it soon goes down and is forgotten.

These cases therefore are not only relevant but they are the only cases that can be cited. So quickly do all prejudicial variations die out that in the wild state only now and then can they be noted and recorded. Hence the exceptional are the only relevant and valid examples, and to reject them on this account would be to put out of court the only witnesses whose testimony is pertinent and by which the proposition can be established.

So far, therefore, is variation from being uniformly beneficial in its results to the variable or to the variant organism, that in not a few cases that come under our observation it is positively hurtful or even fatal. And these must be only a few out of all that actually occur, inasmuch as they are necessarily taken for the most part, indeed almost entirely, from animals and plants in a condition of domestication.

In domestication also a new and almost omnipotent factor enters the problem—human selection. Now if this beneficial tendency in variation had any existence, it might be expected to show some sign of its action in species under human control. Yet here no trace of it can be detected. When a cattle-breeder attempts to develop certain features it would be evidently beneficial that the stock should vary in the required direction, for failure to do so is quickly fatal. Yet immense care and pains, and the constant elimination of faulty individuals are requisite to obtain success in the endeavor. So with plants. In the attempt to establish a new variety of cabbage or lettuce, years of work are essential and thousands of "rogues" must be pulled from the seed-bed and destroyed before the strain desired attains persistence and perpetuity.

IV.

Beneficial Variation and Natural Selection inconsistent.

It is further worthy of remark that supporters of the theory of evolution alluded to in the extracts given above can find no use in their system for the subsidiary doctrine of natural selection. Maintaining a beneficial tendency in all variation guiding it in a channel favorable to the variant, they cannot logically admit the directive influence of selection. All variation being favorable, there can be no forms to be rejected. Yet one at least of the writers quoted is evidently an adherent to the doctrine and admits that its action has much influence in determining the surviving individuals. Were directive beneficial variation a fact, all variates must be equally well adapted to their environment though different from each other. So evident is this that proof is needless. Yet Prof. Gray himself appeals to the action of natural selection in his "Darwiniana," where with a beautiful metaphor he writes:

"Natural selection is not the wind which propels the vessel, but the rudder which by friction—now on this side and now on that—shapes the course. The rudder acts while the vessel is in motion, effects nothing when it is at rest. Variation answers to the wind."

Directive beneficial variation and natural selection are logical contradictories, and cannot both exist. The former if real must be universal. But I have shown that it is not so. Hence every evolutionist who adopts the theory of natural selection must abandon that of beneficial variation, and *vice versa* every adherent to the theory of beneficial variation is unable to admit the agency of natural selection in any of its forms.

V.

Indefinite Variation.

The instances already given have sufficiently illustrated the fact of prejudicial variation. Of beneficial variation no evolutionist entertains any doubt. To dwell on it will therefore be needless. But there is a third aspect of the change which must not be omitted. As we have seen, the gain or loss of an organism by varying may be of any degree from that which gives the variate a surpassing advantage and predominance over his fellows to that which leads straight to extinction. In mathematical language the range of variation is from positive infinity ($+\infty$) through zero to negative infinity ($-\infty$). We must consequently admit the existence of variation which confers no advantage and inflicts no disadvantage on the variant—neutral variation it may be called. This neutral variation is an important factor in the problem, though hitherto it has received very little attention. It is capable of explaining some difficulties, of removing some anomalies. Darwin has alluded to it in a single passage: "I am inclined to suspect that we see in polymorphic genera variations in points of structure which are of no service or disservice to the species" (Origin of Species, p. 46).

Variation of the kind now under consideration may be often seen among the domestic animals where the struggle for existence is less severe and controlled by other laws than among the wild species. For example, six-toed cats (see "Nature" for 1886 and 1887) are a not uncommon though usually a local variety. The peculiarity is freely transmitted. Yet no ill effect seems to attend the irregularity. Indeed if, as asserted, they are good mousers, it may confer a slight benefit though it detracts much from a light and graceful appearance. The same variation is not uncommon among mankind, is there also freely transmitted and is also equally inert in result. The tailless Manx cats may also be quoted in the same connection,* the great range of color in the domestic animals and the manifold shapes of the leaf in many of our garden vegetables which are reproduced with certainty and seem to work neither good nor evil to the plant.

Among wild species the same fact may be noted.[1] Great difference may be seen among the leaves of any species of our forest trees attended with no perceptible advantage or disadvantage. In these cases we need not be surprised to see the variates living side by side with their unvaried ancestors. The red maple of North America is a striking instance. This tree, whose remains are found fossil in the Miocene strata, yet lives in company with its more highly developed and later variates which do not occur in the fossil state.

On this principle I would explain the fact brought forward by Dr. Carpenter of the existence of ancestral forms of *Orbitolites* alongside of later

*In a case that recently occurred under my own observation a single kitten of a litter was born without a tail. It is now nearly full grown and appears to suffer no inconvenience from the curtailment. In a similar way the Manx cats may have originated.

variates. We have but to admit that the changes which occurred to the earlier variable organism were attended with little or no advantage, and that consequently the variable shows no diminution or tendency to extinction by the side of its more specialized variate offspring and the difficulty entirely disappears.

We are compelled to admit variation of all degrees ranging from that which rapidly kills off through that which is absolutely neutral to that which puts its variates at so great an advantage above their fellows that they soon leave them behind and become the "Winners in Life's Race."

VI.

The Cause of Variation.

For a variation so wide in its range as that above described a cause equally wide must be sought. No narrow or arbitrary limits can be set to the cause of a universal consequence. And what more natural or more obvious cause can be suggested than the changes constantly occurring in the environment of the organism? This is of course not a new suggestion, but some writers on evolution seem afraid to carry it out to its full extent. They seem unwilling to abandon the organism to the uncontrolled, confused and seething waves of the sea of physical nature. Yet only in the ceaseless, never repeated tossing of this unresting sea can be found a cause at once sufficiently changeful and far reaching to correspond with the observed changes of the organisms that are borne upon its surface or that live among its waters. Elsewhere in vain do we look for any means of explaining them. All other known natural causes are insufficient and to resort in a difficulty to the unknown and the supernatural is to place the enquiry beyond the pale of science.

In the changes of the physical world therefore and in these alone do we find a cause even presumably sufficient to account for the continual and contemporaneous changes in organic beings. It would be idle to assert that we know the precise mode of action in which the former produces the latter. So new and unexplored is this field that such knowledge is at present impossible. But with every advance we see more and more probability that in the one we have the real and efficient cause of the other. Experiments on the influence of food, temperature, light and other physical agents upon the modification of organisms especially during the formative part of their existence are gradually giving us a mass of information which has already greatly modified former opinions. Some forms once ranked as distinct varieties or even species are now known to be mere accidents resulting from the conditions in which part of their previous existence was spent. Especially is this true with regard to the lower forms.

Time and space will not allow many quotations. One or two must suffice.

"The Mexican axolotl is a tadpole-like animal of considerable size which lives in the water, breathes by gills and is reproduced from eggs.

In its native country this animal is not known to change its form but hatches from the egg into a minute object much like a young tadpole and gradually grows to the form and proportions of the axolotl.

"Now in 1867 the astonishing fact was observed at the Jardin des Plantes that some of these animals cast their skins after crawling out of the water and began a new existence in the shape of a common salamander (Amblystoma).

"This change from axolotl to salamander is accomplished in from fourteen to sixteen days and may, it seems, be always brought about in healthy specimens by placing them in shallow water and gradually diminishing the supply.

"Since these axolotl-descended salamanders are of precisely the same species as other salamanders in the western part of the United States it seems certain that these wild individuals are descended from axolotls and it has been suggested that a dry season or a succession of such seasons first caused the change to take place. If so we have here a striking instance where change of climate has produced not merely another species but another genus.*

The following case given by Schmidt in his work "Descent and Darwinism" I borrow from the author last quoted.

"At Steinheim, in Wurtemberg, was once a small lake and in its waters grew countless little shellfish many of them water snails like those of lakes and rivers at the present day. By the appropriation of the limestone dissolved in the water of the lake generation after generation of these snails built up their shells only to let them fall to the bottom on the death of the little inhabitant. By this slow process a layer of shell-mud was formed which has, since the deposit was made, hardened into chalk. About forty distinct layers of this chalk differing from one another slightly in appearance may be distinguished and throughout these layers are the perfectly preserved remains of many shells. The shells of each layer remain much the same throughout its thickness but toward the upper limit of each they are observed to vary, so as to approach the form which will be found in the next layer.† And not only are the shells of the lowest layer so different that if the intermediate forms had not been discovered they would certainly have been called different species but there are also many among the intermediate forms themselves which if they had been found separated from the others would have been counted distinct."

A figure accompanies this account which exhibits the progressive change from a flat, discoid, planorbiform shell at the base of the deposit to one with a much elevated spire at the summit. A more striking instance of invariance in monotonous conditions followed by variation on the ensual of physical change can hardly be imagined. †

* Bergen, "The Development Theory." See also Buckley's "Winners in Life's Race."

† Mr. W. H. Edwards, of West Virginia, has recently demonstrated similar facts in regard to several species of the Butterflies. He has shown that several forms hitherto considered distinct are in reality only seasonal or other variates. See his "Butterflies of N. America" and his numerous papers on the subject in the "Canadian Entomologist."

Facts of this kind fully and fairly considered (and geology is yearly bringing them in great numbers before us) urge us strongly to the belief that great results are constantly wrought in an organism by physical changes in its environment, and failing evidence of any other agent competent to effect them it is not irrational to ascribe to the same cause all the variational changes. We may then view the organism as plastic material in the hands of its environment, shaped by it entirely and absolutely, and owing its form to its external conditions. Resuming the mathematical illustration the organism is a variable quantity; the physical conditions around it are the causes of its variation; in response to these it varies and after an uncertain period of variancy it becomes another—a Variate.

In thus attributing all changes in an organism to changes in its environment we are under no obligation to admit that such changes are or must be favorable. The physical world exists in total independence of the organic. It was before organization and may be after it. So far from serving or aiding it, phenomena lead us to the conclusion that animate nature is, as it were, permitted by and during certain states of inanimate nature. Within certain limits of temperature, light, etc., organic beings can exist. Beyond those limits their existence is impossible. The organism is, so to speak, an accident among its physical surroundings. If these are compatible with life it lives, if not it dies. It exists on sufferance and its existence is lengthened by its power of adaptation—by its variability. If physical changes ensue the organism must adapt itself to them if it can, and continue in being. If it cannot do so it becomes extinct.

Summing up results thus far obtained we reach the conclusion that the doctrine of evolution by variation in a definite beneficial course is not in consonance with the facts of Nature. On the contrary we find that this variation both of animals and plants appears to take place in every direction indifferently and quite without regard to the welfare of the variant. We find further that no cause is known to which these changes can be referred except the accompanying changes in the physical world. To these accordingly we refer them, conscious at the same time that the exact method of their action is as yet largely unknown.

Further we find that the changes thus produced may be either beneficial, neutral or injurious to the variant organism, following, as they do, certain physical laws which are, if the expression may be allowed, totally indifferent to its welfare. In a word, adopting again the language of mathematics, we may say that the Variate is a function of the original Variable dependent on its constitution and the conditions of its environment—that the changes between the Variable and its function, the Variate may be beneficial in a high or low degree; and may lead to its extension and increase; they may be neutral and leave the organism where they found it; or they may be prejudicial and lead to its diminution or extinction. In every case, however, they are necessary consequences of the interaction of the laws of organic nature within and of physical nature without the organism, inevitable, inexorable, fatal.

VII.

A Possible Objection Considered.

It will not improbably be objected that in thus attributing organic variation *entirely* to outward agency I am going considerably beyond what can be proved. In the strict sense of the term this is true. We cannot yet demonstrate all the effects of physical change on a variable organism. But we are constantly seeing more and more clearly the immense effects of physical nature on organic beings. And experiments, purposed and accidental, are gradually enabling us to trace special organic changes to their causes in inorganic nature, and thus, as it were, to correlate the kingdoms. A vast field of experiment lies here before us in the attempt not merely to correlate but to commeasure these two, not only to determine what physical changes produce certain organic effects, but to measure both, to estimate and weigh them and at length to predict the organic effect of any given physical cause.

And in this direction modern biological research is tending. The results already obtained warrant the hope that some day the present chaos will be reduced to order, and the changes of organic nature will appear as only the outcome of contemporaneous or antecedent changes in the physical world. A correlative and commensurate scale will be established. Rest in inorganic nature, if possible, will be accompanied with invariance of organic nature, for as said above, no "tendency to vary" exists. On the other hand change in the former, if uncompensated, must as certainly induce change in the latter. The induction is not complete, as no induction ever can be, but the number of instances is already so great and so rapidly increasing that the conclusion cannot be called premature, and while every day increases its probability.

It is true that we cannot as yet show many examples of invariance through very long periods of time. Species die out and others come in. Change is the rule, and we have so far found few exceptions. But the biologist does not stand alone in thus advancing a step beyond the cover of "bald facts." Other students in other departments are accustomed to do the same, and boldly to accept the logical outcome of their observations even in cases where for want of opportunity the crucial experiment cannot be performed. A mechanical illustration will make the meaning clear. The first law of motion is thus expressed by mechanicians: "A body continues in a state of rest or of uniform rectilinear motion unless acted on by some outside force." Yet the mechanician has never seen "a body in a state of rest or of uniform rectilinear motion." His faith is nevertheless unshaken. He argues that as every approximation to the necessary conditions is followed by a nearer approach to such motion if he could obtain perfect conditions, perfectly uniform rectilinear motion would result. The force and justice of his argument are admitted. And on proof like this he builds his science of mechanics, and on this science the works of the engineer confidently rest.

PROC. AMER. PHILOS. SOC. XXIV. 125. Q. PRINTED MAY 21, 1887.

Now conceive an organism as the moving body, the motion of the latter being represented by the specific life of the former. As the moving body travels through space, so the organism travels through time. If unaffected by outside disturbing force the former continues in a straight line. So if unaffected by changes in its environment, the latter remains unvaried from generation to generation, merely changing its position in time as the former in space. Thus each would continue indefinitely, the same in all respects except position, after many thousand years had passed away.

But on its way the flying body approaches some other mass of matter, and immediately feels an influence by which its own motion is modified. So on its way through time the organism comes into a different environment to the influence of which it responds by modification of structure or habits or both. These modifications are the necessary consequences of the changes in its surroundings. In the former case we call them physical, in the latter natural. But in neither do we know anything of the mode of working. Of the "why" and the "wherefore" of both we are equally ignorant. The mechanician sometimes imagines that by attributing the one to "universal gravitation" he has explained it. But he has not. He knows nothing of the nature or of the cause of this universal gravitation. The biologist is not yet sufficiently advanced to generalize variation and give a definite name to its cause. But with this unimportant difference the two are in the same predicament.

The parallel may be followed a step farther. The body moving through space and the organism through time are alike in another respect. The former may be drawn forward and its motion accelerated by an outside force. So the latter may vary and improve under the influence of environment. The former may be retarded and its motion may be diminished or destroyed. So by unfavorable environment the latter may vary in a prejudicial manner until extinction ensues. Yet again the former may, under the influence of the disturbing forces, change its direction without either acceleration or retardation. So the latter may vary in directions which shall be perfectly neutral in their effect upon its welfare, and the new form may be as capable of survival as the old. In both cases the variable is perfectly passive and plastic in the hands of its environment, and the environment is perfectly indifferent to the welfare of the variable. The ensuing variate is an outcome of the conditions of the world around it and must take its chance among them, living if in harmony, or dying if in discord.

In both the above cases the crucial experiment is beyond our reach. To obtain absolutely uniform rectilinear motion there must be only one body in the universe, and no resisting medium. To obtain an absolutely unchanging variable organism there must be no alteration of the conditions of existence. Both are alike unattainable. Yet, as with the mechanician so with the biologist, every approximation brings him nearer to the desired result. The vertebrates are least capable of enduring changes of environment, and land surfaces afford the most variable conditions of life.

Among the vertebrates, therefore, of a terrestrial fauna occurs the most rapid evolution of animal forms. The depths of the sea are the places where conditions vary most slowly. The lowest forms of animal life are least affected by changes of environment. Accordingly among low forms of life, and at the sea-bottom, we find most persistence of type. Illustrations might readily be quoted, but they are needless. The facts are familiar to every naturalist. And reasoning from these facts in the same manner as does the mechanician the biologist argues that could he obtain the requisite unchanging conditions his species would continue unvarying for an indefinite time. Though still variable they would be perfectly invariant.

VIII.

Nature's Waste of Variates.

Nature's variates thus produced take their place among their physical and organic surroundings. With these they are more or less in harmony and in discord. If they can, they live; if not, they die. Nature has no care for her nurselings. She casts them adrift on the world to shift for themselves; to swim if they can; to sink if they cannot. She neither aids nor hinders them. She "cares for nothing." It is a game of "hit or miss;" a method of "trial and error."*

If a somewhat homely simile may be here allowed I will liken the process of Nature in producing variates that are in harmony with their environment to the plans adopted by large commercial houses in making their goods known. Not knowing where their customers can be found they scatter advertisements wholesale over the country. Here we find the name of the firm in a newspaper, there at a railway station, here in a magazine, there on a blank wall, here on the fly-leaf of a book, there on the back of a railway ticket, in one place on the pavement underfoot, in another on the ceiling overhead, now on a handbill forced on us in the street, then around the pages of a railroad guidebook, and sometimes even on the fences and the rocks in little frequented spots. Everywhere crops out evidence of a systematic effort to catch the eye of the public by dint of irrepressible advertising without definite method. Of all these attempts the greater part are doomed to failure. Overlooked by the eager readers of the news-sheet and of the railway guide, trampled under foot by the hasty passenger in the street, read and immediately forgotten by the preoccupied and the thoughtless, they live out their little lives as variates among uncongenial conditions, as seed in stony ground, and pass

* It is to this neglect of her variates that the slowness of Nature's results are due compared with the rapidity with which varieties are obtained by man. A valuable seedling grows up in some out of the way place; man secures it, propagates from it and so perpetuates the variate. But if left to Nature it is probably destroyed and the opportunity lost. Every variety and, still more, every species of Nature's making may fairly be looked on as the result of many experiments undertaken and brought to the verge of success only to be abandoned and fail.

away without remembrance or result. But here and there one out of the great number catches the eye of some one in want of the thing advertised. It brings him in as a purchaser and a sale is made. One success out of a myriad of failures. Yet the purpose is served and the business maintained.

So with nature. She launches into the world her countless hosts of variates—in form, in color, in size, in strength, in bodily and mental qualities. Of these, myriads—perhaps the great majority—die and leave no trace. But here and there an individual possessing characters more in harmony with its environment than those of its ancestors or relations takes advantage of the fact, increases rapidly and finally in the struggle vanquishes them and takes their place. The old organism yields and the variate is called the new species. Such is the method of trial and error employed in Nature if we judge impartially from the facts that meet our eye in every field of the organic world.

Strictly speaking every individual is a variate, for never does the offspring in all minute points resemble its parents. But when out of these hosts of variates all the unfit have been eliminated how few remain. How few even among the human family live to manhood, and how much smaller is the number among the wild species. Nature appears to keep in her workshop moulds of almost every conceivable form, and in these moulds she casts her variates, issuing them broadcast on the world in order to see which can survive. The greater number perish. Only here and there does one prove to be in harmony with its environment and live. But those that perish are quickly destroyed and forgotten—melted down and recast—while the survivors apparently testify by their fitness in favor of special adaptation.

IX.

Creation by Beneficial Variation and by Special Design.

In this prodigal waste of her variates therefore rather than in their economical production by beneficent variation, we find the clue to Nature's method of creation. She does not make a new variate in perfect harmony with its surroundings and then carefully watch and nurse it into growth and supremacy. She does not study the surroundings in order to make the variate. Still less does she fashion the surroundings to fit the variate. On the contrary her plan is to produce her organisms in vast numbers, and of varied forms and leave them to be assorted by the sifting process of natural selection. The unfit many soon perish. The fit few alone survive and multiply. The result is that nearly all living species thus sifted out are in a harmony so nearly complete with their environment that it seems at first view intentional. And this is the fallacy underlying the argument of the teleologist, whether he belong to the school of "beneficial variation," represented by the writers quoted at the outset of this paper, or to that older school that formerly pressed and whose adherents still press, though

with somewhat diminished confidence, the famous arguments for "creation by special design."

These writers maintain that the adaptation of an organism to its surroundings is a proof of a specially designing intelligence. They say that the countless instances of accommodation discoverable in existing nature and those which may be inferred in past ages could not have come to pass except by intent. It is needless to quote examples. They are familiar to everybody. They have been enlarged on from the days of Paley's watch picked up on a common down to the present day. And even now books issue from the press reasserting and attempting to reinforce this old argument. Yet from the point of view here taken this "argument from design" is entirely illusory and obtains all its apparent importance and its seeming strength from being based on a mere partial view of the subject. The teleologist picks out instances of organisms that are in harmony with their surroundings, sees and studies the many and minute adaptations of the one to the other, and then somewhat hastily infers a special intention in the arrangement. From the examination of a few instances he infers a general rule and asserts that every organism is specially adapted to its environment by intelligence. The inference is natural, obvious and pardonable on a superficial view, but wider and closer observation refutes it. Every organism is in approximate harmony with its surroundings because, as said above, it lives only on that condition. If not it dies. This fact the teleologist fails to see or to appreciate. By him the constant struggle for existence is unseen, the cries of the vanquished are unheard, the thousands that are born only to die of unfitness are unnoticed. Were all these elements taken into account his problem would be less simple and his results less easily reached and less confidently announced. Special intention or design in creation could hardly be affirmed of a world where the greater part of the experiments fail of success.

Returning for a moment to the illustration employed above, the teleologist is in the position of one who seeing an advertisement fall into the hands of a man in need of the article advertised should straightway infer a special design in the advertiser to bring these two together. Not seeing or not heeding the thousands that went to waste he comes to a hasty and incorrect conclusion by imperfect induction. A wider view would give a juster sense of the relation between the failures and the successes and enable him to see the design, for such it may fairly be called in its true light.

For, be it understood that evolution as here defined by no means disproves design. To assert or to imply this would be as illogical as the fault just condemned, but in the opposite direction. That it disproves "special design" is, it appears to me, evident. But design of another kind and of a wider scope, working in quite another fashion—"the method of trial and error"—may yet exist behind all. On this question evolution thus far speaks doubtfully and the biologist holds no positive opinion.

Of one fact, however, he is confident—that all the changes of organic

life are results of unswerving "natural law," the details and modes of whose working he cannot yet trace. Chance at present seems supreme among the tranformations which evolution has revealed. But chance is only a name under which we disguise our ignorance. In a world under the action of universal natural law, Chance, that is, causeless effect, cannot exist. Chance in this sense is to the careful student of Nature unthinkable, inconceivable. Every event is a consequent of antecedents and an antecedent of consequents. Order, such as it is, prevails everywhere. The sequence is unbroken. Every existing species is a single link of a chain, one end of which is lost in the distant past and the other end has not yet emerged from the distant future. Every link depends from that preceding it and serves as a point of attachment for that which follows. What the one is the other will be, barring the effect of outside influences, and could the exact nature of the organism be known and the exact effect of environment be determined, it would be possible to foretell the exact nature of the ensuing variate.

But firm as is the faith of the biologist in the existence and ceaseless action of universal law he admits his utter ignorance of that deeper force or of those deeper forces that keep the law in action. This must be determined from the working of the law itself. He must reason back from the law to the underlying principle and determine the nature of the latter from the mode of the former. And if in this profound investigation he finds himself coming to results which clash with prevalent or preconceived opinion, if the law of the universe seems other and harder than poets have feigned, yet sentiment and prejudice should not be allowed to lie as stumbling-blocks in the path of advancing knowledge, nor should the faint voices and dim lights which come to us out of the darkness ahead be disregarded, though they would lead us in different direction from that in which we were wont and wishing to go.

Conclusion.

A possibility looms up before the biologist on this view of his science which no other theory can encourage. If all organic changes come about as consequences of changes of environment, why should it be beyond reasonable hope that he may some day be able to grasp the effects of the latter so completely as to foretell the former? Astronomy was once in the state of confusion and ignorance in which biology now lies. The movements of the planets were an unsolved enigma, their paths a tangled maze, their mutual influences a seemingly hopeless chaos. But Copernicus, Kepler, Galileo, Newton, Laplace and Leibnitz arose. The key of the enigma was found, the clue to the maze, the order in the chaos. And now of all the physical sciences, astronomy is the most exact, the most thoroughly under control of mathematical laws. The astronomer, rising above the task of merely recording the past, predicts the future. The movements of the planets are understood; universal gravitation enables him to grasp them, and the subtle mathematical analysis gives him the

means of seizing any one of them, of tracking it through space, of marking its course, of including the varying effects of other globes, and finally, from his complicated formula, he educes a prediction of its place at any moment in the future.

Is it too much to hope that some day the biologist too will rise to the same position; that some other and greater Darwin will be born to give us a generalized law of variation; that some biological Newton will arise and enable us to compute the complicated problem which organic beings present in passing through their different stages of variation? If even now the pigeon-fancier will undertake to produce in a given time a bird with any desired plumage (within possible limits); if the cattle-breeder can call into being a variety retaining desirable and excluding undesirable qualities; if a gardener can develop a new and valuable variety of plant, and fix its characters so that it comes true from seed for many years, why should we not hope that some day the special will become the general, and that what can now be done in a few cases will then be done in all at will? When the effects of changes in the environment are definitely known and traced back to their special causes, their direction and amount determined and their condition so fully understood that they can be reproduced at pleasure, then will the material be in our hands for the final generalization. Is it too sanguine to hope that a biological analysis will then be invented and perfected as mathematical analysis has been perfected, and that the biologist, armed with this new engine of investigation, will be able to trace the past evolution of organisms to its causes in the organic world? And, bolder still, may he not venture into the future, seize in the grasp of his Calculus any variable organism, and involving in his formula the successive conditions of its environment, trace it through its complicated changes during its period of variance until his equation yields up the function—the variate—at the end of any desired interval, exhibiting new characters and forming a new species?

Is such a prospect, though distant, altogether visionary? May we not hope some day to solve the great evolutionary problem? Given, a variable organism and the conditions of its environment during a certain time, to determine the consequent changes.

THE MEDICAL MYTHOLOGY OF IRELAND.

By James Mooney, Washington, D. C.

(Read before the American Philosophical Society, April 15, 1887.)

NOTE.—The information contained in the following paper has been obtained by the writer's personal investigation among the people who believe and practice the things described, and has not been obtained from books, although numerous works bearing on the subject have been consulted. Every belief and custom described is still in vogue in some part of Ireland, especially in the west. They have even been transplanted to this country, and some of the charms mentioned have been used by Irish men and women for the relief of children at the request of fairly intelligent American parents, while the accidental death of a young man at Holyoke, Mass., some years ago, is attributed by his friends to the evil eye of a Mearnan who was near him at the time. Where inquiry among people of different sections has shown a custom to be general, the fact has been stated, and most of the charms described as local would probably prove to be generally known on further investigation.—THE AUTHOR.

For several reasons the mythologic theory of disease has probably reached its highest development and retained most of its original strength among the people of Ireland. Her national life was crushed into the ground by an alien tyrant while still the gloom of the Dark Ages hovered over Europe, and when the Irish nation itself had hardly emerged from the tribal condition. The island which had been the home and the refuge of scholars during the troubled centuries which followed the fall of the Roman empire was given over to desolation, and the fire kindled upon the altar of learning went out in blood and tears. Laws were enacted against the dress, the language, the very names of the people, and it was held no crime to kill an Irishman. Schools and monasteries were despoiled and their inmates hunted down like wild beasts or banished from the country—the same price was offered for the head of a priest and for the head of a wolf—and for nearly seven hundred years teaching was a treason and education a crime. When at last, within the present century, the laws became at least human, and schools were established throughout the country, the same landlord system against which the Irish people are now fighting fastened them down with a weight of poverty which their utmost exertions were not sufficient to throw off. The people had no time or money to go to school, and therefore remained in a great measure uneducated. In addition to all this must be considered the peculiarly spiritual temper of the Kelt, and especially of the Gael, which inclines him to a strong faith in the things of the invisible world, and renders the Irish nation an eminently religious people. The same qualities, when not properly directed by education, lead naturally to superstition, the religion of ignorance.

If a line three hundred miles long be drawn through the greatest extent of the island, from Inishowen in the north to Cape Clear in the south, it will divide the country into two parts, of nearly equal size. The eastern

section is a fertile plain, shut in by low mountains along the coast, and being naturally easy of access and more exposed to foreign influence and colonization, its inhabitants have lost much of their original character and nearly all of their language. The western section is chiefly a region of rugged mountains, and limestone cliffs covered with a thin layer of soil, where no one but an Irishman would attempt to raise a crop. Its inhabitants, who are fishermen on the coast and shepherds in the mountains, are still in the primitive condition of their ancestors, retaining in a great degree their simple habits and their Gaelic language. The typical districts of this region are Donegal in the north, Kerry in the south, and Connamara in the extreme west. Here the practices and beliefs which were once general throughout the country still have full sway, the enchanted horse dwells in the lough, and the fairies dance under the hawthorn.

The Practitioners.

In describing these customs and beliefs they will be treated, not as half-forgotten superstitions raked up out of the past, but as living realities, for such they are in fact. The medical professors of this region are generally old women, whose stock in trade consists of a few herbs and simple decoctions, a number of prayers and secret formulas to be recited while applying the remedy, and a great deal of mystery. Such a woman is commonly called a *cailleac' luib'e** "herb hag" or *bean feasac'*† "knowing woman." When her art is of that doubtful kind which tends rather more to the injury than to the good of her neighbors, she is called a *piseog*‡ and the same name is also applied to her nostrums. In some few cases the doctor is a man. There are also a number of persons who have cures for particular diseases, these cures being innate in the individual, owing to some accident of birth, or hereditary and transmitted from parent to child from a remote generation. When hereditary, the secret is jealously guarded—even by the mother from her child—and only revealed upon the deathbed, to some one of the family who, at the same time, is pledged to silence. For this reason it is almost impossible to get the formulas used with any of these cures, but there are a number of charms in use which are common property, and from a knowledge of these the character of the others may be guessed. In rare instances the possessor of a cure bestows it upon another in return for some favor, the charm losing none of its efficacy by the transfer. It is generally considered essential that the charm should have been inherited from a woman by a man, or from a man by a woman. Persons who possess these single cures give their services

* Pronounced *cawl-yakh liva*. The Connamara pronunciation is given, unless otherwise noted. In the Gaelic text the aspirated consonants are indicated by a dot placed after them near the top. When the Irish characters are used the dot is placed above the aspirated consonant, and when the Roman characters are used, as in Scotland, the consonant is followed by an *h*. The *h* is not here used, as it does not properly belong to the Gaelic alphabet, and gives a false appearance of harshness.

† Pronounced *ban fasakh*.

‡ Pronounced *pishoeg*.

freely, as their powers are looked upon as sacred gifts which would depart from them were a fee demanded, although they may accept a small present. The other class, on the contrary, who are considered as akin to dealers in the black art, act upon the principle of "nothing for nothing." In Connamara it is customary to cross their hand with a two-shilling piece, a silver coin having a cross upon one side, the sacred emblem being supposed to compel them to speak the truth. The herbs are gathered fasting, generally by moonlight, and whisky enters largely into the decoctions.

These practitioners have their specialties, and one who deals with the evil eye will have nothing to do with a fairy sickness, neither will the "fairy woman" meddle with an illness which is due to the influence of the evil eye. It must not be supposed, however, that the people depend entirely upon the skill of these doctors. On the contrary, every housekeeper is well acquainted with the virtues of all the common herbs, to which she never fails to resort in case of need—always accompanying the application with a prayer—and it is only when she has exhausted her resources or is convinced that the sickness is of supernatural origin, that she applies to the *cailleac' luib'e*. When an ailment does not yield readily to simple treatment, it is generally ascribed to one of three causes, viz., the fairies, the evil eye, or witchcraft. The last of these is not often held responsible, as Irish witches usually confine their operations to stealing the butter, and seldom harm the owners. We will speak first of the fairies.

The Sig'efreog and Fairy Influence.

The person, of either sex, who treats illness of fairy origin is called a *sig'efreog*,* the name being probably a diminutive of *sig'efear*,† a "fairy man." In the south they are called *sheefers* or *sheefros*, while in the east they are known as fairy men or women, as the case may be. They have generally obtained their knowledge by a residence of some years with the fairies, who frequently carry off both grown persons and infants, and detain them for three, five or seven years, unless forced to return them sooner. Young mothers and their infants are especially liable to be abducted, and to prevent such a calamity numerous precautions are adopted, which need not be described here. The health—at least of grown persons—is in no way affected by their sojourn among the fairies, while they learn all the secrets of their captors and afterward use this knowledge to defeat their purposes. Although, after returning to their friends, their services are in constant demand to counteract the fairy influence, they are never able to shake it off from themselves, but are frequently called away, even in the dead of night or from the midst of a company, to perform some office for the "good people"—generally to wait upon a fairy mother or her child. The fairies naturally resent the interference of

* Pronounced *sheefroeg*.

† Pronounced *shee-fär*.

the *sig'efreog*, and while gathering her medicinal herbs she is frequently stricken with convulsions and falls to the ground, foaming at the mouth, owing to the violence of her struggles with the invisible beings, who strive to tear the plants from her grasp. In one instance, in the County Clare, they seized a man at night in a lonely place, and beat him so terribly that he was confined to his bed for a week afterward.

In addition to her medical knowledge, the *sig'efreog* can read the thoughts of others, and tell the whereabouts of missing articles, and her powers are often inherited by any of her children who may be born after her return from fairy land. She also warns the people occasionally against doing anything which would incur the ill will of the fairies, such as throwing out dirty water after nightfall, when the elves are engaged at their sports; forgetting to leave clean water on the dresser for them to drink; or saying grace over the potatoes without first setting aside a portion for the fairies, who cannot touch consecrated food. Such is the dread of offending these spirits that they are seldom mentioned under their true name of *sig'e*,* or "fairy," but are generally called *daoine mat'a*,† or "good people," frequently accompanied by the invocation, *Fogramuid deag'-c'om'arsanac't oraib'*,‡ "we beg good neighborship of you."

The supernatural power of the *sig'efreog* is sometimes due to some remarkable cause other than a residence with the fairies. In the County Clare is a wild mountain lake known as Lough Doon, where St. Patrick confined the last of the serpents which still at rare intervals comes out upon the bank. On one of these occasions the serpent was seen by a man who ever afterward "had a cure." There formerly lived near Tuam, in the County Galway, a cripple known as *Dom'nal Crom*,§ or "Crooked Daniel," who, on account of his infirmity, was generally appointed to watch his neighbors' cattle upon the mountain side. While thus engaged one day he saw a bull descend from the heavens and associate with one of the cows. By drinking the first milk drawn from the cow after the birth of the calf he was endowed with a knowledge of fairy doings and the gift of prophecy.‖

A single instance, from east Galway, will serve to illustrate the manner of fairy seizure and rescue. A woman was carried off while her husband was out of the house for a short time, and on his return, instead of the blooming young wife he had loved, he found a shriveled whimpering creature, who would take no care of the child. He was in great trouble over the matter for some time, until one night, as he was coming across

* Pronounced *she*.

† Pronounced *dheenee mŏha*.

‡ Pronounced *Foegramŭj jaw-khoersanakhth ŭriv*.

§ Pronounced *Dhonawl Orum*.

‖ This man is referred to on page 83 of Sir Wm. Wilde's valuable and interesting work on Lough Corrib, published in 1867. The account here given was obtained from a native of that vicinity.

the field, he saw his wife standing in the *haggart*.* Going up to her, he asked her, in the name of the Trinity, who had her in their power, and what he must do to rescue her. She told him that she was with the fairies and that there was one way by which he could recover her, if he had sufficient courage to try it. On a certain night and at a certain hour, a company of mounted fairies, with her in their midst, would enter a fairy fort† near his house. He must be ready with some urine and some chicken dung, which he must throw upon her and then seize her. He promised to do as directed, and at the appointed time he was in waiting near the fort. Soon he heard the fairies approaching, and when the noise came in front of him he threw the dung and urine in the direction of the sound, and saw his wife fall from her horse. He seized her, and although the fairies crowded around and strove to tear her away from him, he defied them and held on to her until they gave up the attempt and retired into the fort, when he brought her home with him. At the instant he seized her there came such a blast that "you'd think the wind would sweep the roof from the house," and in the midst of it all the withered hag disappeared and was not seen afterward. The woman lived to a good age and had several children after her return.

The method adopted in this case to break the power of the enchantment is especially to be noted, as it is a cardinal principle in Irish mythology that fairies, being pure spirits, cannot endure defilement. Even a handful of dust thrown into their midst will sometimes cause them to release their hold on a prisoner. The same ingredients enter into most of the charms and amulets used as a protection against the fairies. The chicken, also, is regarded as peculiarly sacred, and some wonderful virtue is connected with everything belonging to it. According to popular belief, the fairies can take anything but a chicken or an egg.

Unusually promising young children—especially infants not yet baptized—are frequently carried off by the fairies, who leave instead what are known to be changelings by their pinched and withered features, their hollow voice, their constant crying and inordinate appetite, and their unnaturally shrewd remarks and actions. In other words, the uninformed observer might think them precocious children in delicate health. In such cases, when there is no longer any doubt in the matter—for mothers are always slow to be convinced of the real truth—the fairy woman is called in to bring back the stolen child. Her usual method is to heat the shovel in the fire, place the changeling upon it and put it out upon the dunghill. She then returns to the house and recites certain words, after which the family go out to the dunghill and find there the real child, in place of the other, which has been taken away again by the fairies. The child seldom

* An outdoor inclosure for storing grain and hay.

† Prehistoric circular earthworks, with underground passages, very numerous throughout the south and west, and popularly believed to be the abode of the fairies. Antiquarians generally regard them as ancient communal village inclosures.

lives long after its return, owing to the rough treatment it receives while in the hands of the fairies.

In this operation we have a combination of fire, iron and dung, the three great safeguards against the influence of fairies and the infernal spirits. Three is also the sacred number in Ireland, as well as throughout Europe. The changeling sometimes leaps through the window at sight of the preparations, and disappears in some unaccountable manner, when the real child is found asleep in the cradle. This method is known throughout the country, but there are also other ways to accomplish the same purpose. In the County Cork the mother, while still fasting, takes the changeling before sunrise to a point where three running streams meet, and after stripping it, dips it into the water three times in the name of the Trinity. This is done on three successive mornings, and on returning home the third morning her real child is restored to her arms as she enters the doorway, the substitution being effected instantaneously by the fairies.

In another instance a young man was suddenly stricken with a rheumatic illness, which confined him to his bed nearly three years. At last one day while his parents were gone to the market he got up and joined the younger children playing outside the house, and was as active as any of them. When it was about time for the parents to return he went back to bed again. The children told the old folks all about it and an elder brother agreed to watch the next day. In the morning the parents started off again, but were hardly out of sight when the sick man was out of bed once more and in the field with the children. The watcher ran toward the house to see if the bed was empty, but with all his swiftness, the rheumatic got there first and was in bed when he entered the door. The brother took up an ax, and approaching the sick man, swore that he would kill him if he did not tell who he was. "Oh, brother," cried the sick man, "don't strike me, for I have only a few more days to serve, and then I will be with you again." The brother desisted and soon after the young man was restored as well and strong as he was three years before. He explained that a servant girl of the family, who had apparently died about a year before the beginning of his illness, was with the fairies, and had warned him not to accept food or drink at their hands. He followed her advice, and at the end of three years, the shortest period of fairy detention, they were consequently obliged to release him, while the girl who had made the fatal mistake of eating with them was never restored. The young man was the son of a respectable farmer named Halpine, in the County Limerick.

This belief in the presence of a fairy changeling in place of the sick person is very general, especially in the case of infants which pine away without apparent cause, strong young men suddenly stricken down, and old persons whose illness is of a fitful and lingering nature. It probably has its origin in the change in disposition and features under such circumstances, and the unwillingness of the people to believe that this can be

the result of natural causes. The supposed fairy is sometimes threatened to force him to reveal his identity, and when the case is evidently hopeless, although the patient still lingers, a piece of *Lus-Mor*,* or foxglove, is put under his bed. If he be a changeling, the fairies will be compelled to restore, at once and in good health, the person taken away. If the invalid be really present in his proper person, he will not recover, but die. The reason of this is, that when the soul, after death, is brought up for judgment, it is sometimes condemned to return and re-animate the body, and endure with it all the miseries of sickness until its sins have been expiated, when it is finally separated from the flesh and enters into eternal happiness. The fairies take advantage of this temporary absence of the soul before the judgment bar to put one of their number into the body so that when the soul returns it finds its place occupied and is obliged to go with them. The presence of the *lus-mor* compels the fairies to take away their spirit from the body and release the soul, which then enters at once into glory. This, of course, is no part of the Catholic belief, but a survival of the old paganism.

Lameness is frequently the result of having intruded upon the precincts of the fairies or interfered with them in some other way. For this reason the people are especially careful not to disturb the fairy forts or venture near them after nightfall. A girl near Feakle, in the County Clare, fell asleep in a fort on a harvest day, and on awaking in the morning found herself unable to walk on account of a painful ulcer on her limb. The fairies had struck her for coming upon their ground. After a long illness something like a thread of flax came out of the wound and she recovered. Ulcers, scrofula and running sores are commonly called "fairy strokes," and attributed to fairy influence. The particles of hardened pus which sometimes come out of the sore are the fairy darts which have caused the wound. A man near Dunmore, in Galway, rented a small farm upon which was a fairy fort, which was overgrown with bushes. As these were never disturbed they at last began to encroach upon the cultivated ground. In spite of the remonstrances of his wife he determined to root out some of them, but had hardly begun the work when he was struck with such a sharp pain in his leg that he fell to the ground and had to be carried into the house and put to bed. His wife went out and replanted the bushes just as they were before, when he at once got relief. This was told by the man himself and confirmed by his wife, who was present and added: "If there is one thing certain, it is that there are fairies in Ireland." He holds a responsible position at a salary of $1300 per year. Near Bandon, in the County Cork, lived a man who in his youth was a noted jumper, and on one occasion leaped across a ditch twenty-two feet in width and alighted in such a manner as to severely injure his foot. A running sore appeared on his ankle and pieces of bone came out. His mother procured from a fairy woman a "bottle of herbs," which was rubbed upon the foot and

* Pronounced *lus-more*; literally the "great herb."

resulted in a cure. The bottle was paid for with a basket of eggs, each one of which was marked with a black cross made with the burned end of a stick, probably of furze. The woman explained that he had been kicked by the fairies, who were passing that way when he jumped into their midst. This woman went every night with the fairies, who summoned her with a peculiar whistle, which was heard by other persons as well as herself. She was once called away from a wake in this manner, but no one had the courage to follow her. The story is given as told by the man who made the leap, an old soldier who has spent the last thirty years fighting Indians and border outlaws on the frontier, and is now laid up for repairs at the soldiers' home near Washington. When a boy he often watched all day at the entrance to a fairy fort to catch a glimpse of the fairy shoemaker, but he says he no longer believes in such things.

Another of these women kept a bottle of water, and by holding it up to the light could tell whether or not a sick person would recover. A man once came to her to inquire about his brother, who was sick. She looked at the bottle of water and said, "You have come three minutes too late." The man went home and his brother died.

When any one sneezes, it is in consequence of a blast from the fairies, who are then endeavoring to carry him off. At the third sneeze they will accomplish their object, and leave a corpse or an invalid changeling in his place, unless some one present exclaims, "God bless us!" On hearing the name of God the fairies take flight, and it is hardly too much to say that this ejaculation is never omitted on such occasions. A similar custom prevails throughout Europe and has been traced back as far at least as the time of Homer.

The prehistoric stone arrow head, or *saige'ad** occasionally found in the country, is a fairy dart which has been shot at some man or animal, and thus lost. The fortunate finder can counteract the designs of the fairies, and the old woman who possesses one is regarded with much veneration, and in the expressive language of the people, "she will get good nursing." When an illness is supposed to be due to the influence of the fairies, the *saig'ead* is put into a tumbler and covered with water, which the patient then drinks, and if the fairies are responsible for his sickness he at once recovers. The *saig'ead* is preserved in some iron receptacle to prevent the fairies stealing it.

As so many physical evils are due to the fairies, it is natural that some means should be used to ward off their influence. For this purpose a horse shoe is nailed over the door, while garlic is planted in the thatch above it. As newly made brides and young mothers are in most danger from this source, a great many measures—which come more properly under the head of marriage customs—are taken to prevent the abduction of either the wife or the child. It may be in order here to state that no fire must be taken out of a house while a woman is sick within it, and

* Pronounced *sedh*, equivalent to the Latin *sagitta*.

there is a general reluctance to lending anything whatever out of the house at such times. The ancient religion of Ireland was fire worship, and numerous vestiges of the old belief still exist among the popular customs.

Scraps of iron are frequently carried as a protection against the fairies, and in Connamara it is still a common practice to wear about the person what is exactly equivalent to the medicine-bag of the Indian. The contents of this bag, which is about the size of a hickory nut, are known only to the owner, who conceals also the fact of its possession even from his most intimate friend, but among them are usually found tobacco, garlic, salt, chicken dung, *lus-crea*, and some dust from the roadside. This is worn also as a protection against the evil eye, and something of the same nature is sewed into the clothing of the bride when her friends are preparing her for the marriage ceremony.

Convulsions in a child are sometimes due to the influence of the fairies, being probably the result of its struggles to escape from their grasp. The theory and practice are best illustrated by relating an instance, which is given just as it was told by the narrator, who knew the mother and believed the story. A woman had a child which was subject to dangerous convulsions, and after one unusually violent attack she consulted a fairy woman, who told her what she must do. On her way home the mother picked up from the roadside ten small white pebbles known as fairy stones. On reaching home she put nine of these into a vessel of urine and threw the tenth into the fire. She also put into the vessel some chicken dung and three sprigs of a plant (probably garlic or ivy) which grew on the roof above the door. She then stripped the child and threw into the fire its shirt and the other garments which were worn next the skin. The child was then washed from head to foot in the liquid, wrapped in a blanket and put to bed. There were nine hens and a rooster on the rafters over the door. In a short time the child had a violent fit and the nine hens dropped dead upon the floor. The rooster jumped down from his perch, crew three times, and then flew up again to the rafters. If the woman had put the tenth stone with the others, he would have dropped dead with the hens. The child was cured.

Vicarious Cures.

This single instance combines in itself a number of important features in connection with the popular mythology—the dung, the urine, the plant over the door, the chicken, the fire and the garment worn next the skin—and introduces also a new element in the popular theory of disease, viz.: the idea of vicarious cure, or rather, of vicarious sacrifice. This belief, which is general, is that no one can be cured of a dangerous illness unless, as the people express it, "something is left in his place," to suffer the sickness and death. A few illustrations from the County Clare will exemplify this belief.

A father, whose son was nearly at the point of death, applied to a man noted for his healing powers, who told him that the boy could be saved but that something must go in his place. "Well," said the father, "take anything that I have but a Christian." The other said it would not do for him to accept anything, but that he would put his own horse in the place of the boy. He then told the father to watch the horse, which was just coming up from the sea with a load of sand. The moment the cart reached the spot where the sand was to be put, the horse dropped dead. When the man arrived at home his son was well.

In another instance a woman was sick, and her husband called in a man who told him to take every living thing out of the house before he proceeded to cure her. The husband put his children out of the house, but forgot "a sow with a litter of *bonnivs*"* in one corner. The other man then recited certain prayers and restored the woman to health, but when the family came back again into the house they found the sow and the *bonnivs* dead.

At another time a man's wife was sick and the operator was sent for. He recited some words and the woman began to recover, but the next morning a fine cow belonging to her husband was found lying in the field, groaning and unable to rise. The cow grew worse as the woman grew better, and when the cow died the woman was well.

In the same connection may be mentioned a custom which prevails among the fishermen of Mayo and Connamara. Every master of a fishing boat carries a dog with him when out at sea, and should a storm arise, the dog's legs are tied together and it is thrown overboard, in the belief that the sea will at once become calm. This practice exists in Ireland to-day, in the nineteenth century, and is exactly what formerly existed among the Indians on the great lakes, as we learn from the trader, Alexander Henry. In 1766, while crossing Lake Huron in a canoe with a party of Ojibwas, a storm came up, which was attributed by the Indians to the anger of the snake god, whom he had offended the day before by attempting to kill a rattlesnake. After calling on the snake god for help, "One of the chiefs took a dog, and after tying its four legs together threw it overboard, at the same time calling on the snake to preserve us from being drowned, and desiring him to satisfy his hunger with the carcass of the dog."† We read in the Bible how, nearly three thousand years ago, the prophet Jonah, fleeing from the will of God, was on board a ship in the Mediterranean when they were overtaken by a storm. After calling upon their several gods, and using every effort to right the vessel, the sailors cast lots to discover who was responsible for the storm, and the lot fell upon the prophet. "Then said they unto him, What shall we do unto thee, that the sea may be calm unto us? for the sea wrought and was tempestuous. And he said unto them, Take me up and cast me forth into the sea; so

* Gaelic, *banab'*, a sucking pig.

† Henry, Travels, 178, 1809.

shall the sea be calm unto you, for I know that for my sake this great tempest is upon you. * * * So they took up Jonah and cast him forth into the sea, and the sea ceased from her raging" (Jonah, i: 11, 12, 15).

Another belief, which exists alike in Ireland and among the Indians, is that certain localities are the abode of invisible malignant spirits, which visit sickness and death upon those who come within their reach. These evil spirits are overhead in the air, and are quite a different order of beings from the fairies, who live upon or under the ground, and on the whole are rather regarded as benevolent. If sickness or death occurs in a new house, it is frequently ascribed to this cause, and the house will be removed, or torn down and rebuilt in another place.

There is also a way by which the pains of maternity can be transferred from the woman to her husband. This secret is so jealously guarded that a correspondent in the west of Ireland, who had been asked to investigate the matter, was at last obliged to report: "In regard to putting the sickness on the father of a child, that is a well-known thing in this country, but after making every inquiry I could not make out how it is done. It is strictly private." It came out, however, in a chance conversation with a woman who, when a child, had once been selected to wait upon a nurse on such an occasion. At a critical moment the nurse "hunted her out of the room," and then, taking the husband's vest, she put it upon the sick woman. The child had hid behind the door in the next room and saw the whole operation, but was too far off to hear the words which were probably repeated at the same time. It is asserted by some that the husband's consent must first be obtained, but the general opinion is that he feels all the pain, and even cries out with the agony, without being aware of the cause.

The Evil Eye.

The belief in the existence of the *evil eye* is general throughout Ireland as well as throughout the greater portion of Europe and Asia. It was held also by the ancients, among whom there were whole nations whose glances were supposed to be fatal, and it was even thought that there was death in the sound of their voices. The eastern nations, both Christian and Mohammedan, ascribe almost every unaccountable illness to this cause; and among the Turks sentences from the Koran are written upon the walls of the houses to counteract it, while glass balls are hung from the ceiling, and gaudy trappings put upon the horses, to divert from the owner the attention of the evil-minded beholder. So general is this belief that a writer upon the subject says: "It is not improbable that if the matter were still more profoundly investigated, it would be found that every nation that exists, or has existed, with anything like a developed system of superstition, believes or has believed in the reality of fascination in some form or other."* There seems to be nothing exactly similar among the Indians, at least among the Siouan tribes of the plains,

*Am. Cy., iv, 177, 1880.

although the belief is said to exist among some Californian tribes. It may be that the idea is too subtle and intangible for the mind of a savage.

The general prevalence of this belief would seem to indicate that there must be some good reason for its existence, and this reason is doubtless to be found in the wonderful properties of the eye itself. We all know how much of attraction, repulsion, love or hate, may be expressed by a glance, and how intensified is this power of expression in certain individuals. There is unquestionably some innate, inexplicable power in the human eye, although more apparent in some persons than in others, and we can readily understand how the people of Ireland believe that every individual possesses this faculty at some period in his existence, and that it is sometimes hereditary, like other physical and mental characteristics. The influence of the human eye over the inferior animals is well known, and much has been written concerning the fascinating powers of the serpent, although in the latter case modern biology has shown that the result is due not so much to the eye of the serpent as to the paralyzing effect of fear upon his victim.

Droc'-s'uil, the "bad eye,"* is the name given to the evil eye in the Gaelic-speaking districts of Ireland, while it is known as the *bad eye* in the east, and the *ill eye* in the north. The act of fascination is called *deanad' droc'-s'uil*†, "making a bad eye," or *overlooking*. Those who possess this blighting power are generally unaware of its presence in themselves, and the evil consequences of its influence are not usually the result of any malevolent desire upon their part. The evil eye, either in man or woman, is generally due to some omission or irregularity in the ceremony of baptism. Should any word of the prescribed formula be forgotten, or should the sponsor fail to give the surname of the child as well as the name about to be conferred upon it, the infant will, in spite of itself, come into possession of this dreaded power. The idea underlying this belief may be that, as the child is born in a state of original sin, it is under the influence of the evil spirit until sanctified by baptism, and that if the ceremony be improperly performed, a part of this influence still remains and manifests itself in the evil eye. In some instances the *droc'-s'uil* is hereditary, and there are even cases where it exists among all the relatives of the same surname. A notable example of this occurs in the western part of the County Clare, where all the members of a family named Mearnan are known to possess an evil eye, even to the remote degrees of kinship. Notwithstanding this, they are much esteemed for their upright character, as it is well understood that this mysterious power is not subject to their own control. This family is referred to, but not named, in Hall's Ireland (III, page 250), a book published about forty years ago. The stories given further on concerning the Mearnans were obtained, with others, from natives of the County Clare, who were well

*Pronounced, *dhrākh-uil*.

†Pronounced, *jeenoo dhrākh-uil*.

acquainted with the family. While the evil eye belongs to some persons in a special manner, every man, woman and child possesses this faculty unawares once in every twenty-four hours, and a single glance at such a time is followed by all the ordinary disastrous consequences. This explains many mysterious cases of sickness otherwise unaccountable.

As has been shown, sickness and death sometimes result from the unconscious glance of one possessed of the evil eye, without any desire upon his part to injure the victim. Should a person, however, known to possess an evil eye, speak admiringly of another, praising his good looks, his healthful color, or his robust physique, or speak in a similar manner of his child, his cow, his crops, or anything belonging to him, it is inferred that he intends evil toward the person or thing thus spoken of, and measures are at once taken to prevent it. In many cases the evil-minded person is compelled by the injured man, on pain of bodily damage, to spit upon the object of his pretended admiration, and at the same time to invoke a blessing upon it. In Connamara a bowl is sometimes sent around the neighborhood, and each person to whom it is presented is expected to spit into it. The bowl is then taken home, and the person or animal overlooked is anointed with the spittle. The object of this is to obtain the spittle of the person responsible for the injury without giving him offense or awaking his suspicion, as a direct appeal to him would be certain to do. When the spittle cannot be procured, the same result is accomplished by burning near the afflicted person a piece taken from the clothing of the one who has overlooked him.

Should any one accidentally meet a person suspected of an evil eye, its influence may be averted by doubling the thumbs under the fingers. This gesture, and the measures just mentioned, are used throughout a great part of Europe for the same purpose. It has been asserted that the closed hand is used from its fancied resemblance in shape to the initial letter of the Hebrew name for God; but while the name of the Hebrew letter also signifies a *hand*, the equivalent Phœnician and Egyptian hieroglyph is an open, instead of a closed hand. It seems also to be of different origin from the ancient Italian gesture still used to avert the evil eye, which is made by extending the first and fourth fingers, and is supposed to have had reference originally to a pair of horns. The true reason for using the closed hand probably lies in the fact that in this position the thumb and finger form a cross. In all Catholic countries it is a common practice to make the sign of the cross as a protection against dangers, especially those which are due to the influence of evil spirits. This sign is usually made upon the forehead, while occasionally the second finger is simply crossed over the first, but the method of the closed hand would naturally be adopted in this case to avoid attracting attention, just as an entire neighborhood is sometimes laid under contribution for spittle in order to avoid giving offense to the suspected party.

When an illness is thought to be due to the influence of the evil eye, the *bean feasac* who makes a specialty of such cases is called in to deter-

mine the matter, and to point out the author of the trouble, but her office seems to go no further, as the mode of cure is generally understood.

Anything which renders an individual conspicuous is liable to attract the attention of the evil eye—a belief also held by the Turks—and this explains some Irish blessings which are intended and regarded as curses. A common one of this kind is, *Go mbeid' ba b'ána do c'uid ba, go mbeid' teac' air an airde do t'eac', agus go mbeid' bean b'reag' do b'ean.** "May your portion of cows be white cows, may your house be a house upon the height, and may your wife be a fine woman." Here the real wish of the speaker is that the conspicuous color of the cattle, the prominent position of the house upon a hill, and the pleasing qualities of the wife, may attract the attention of the evil eye to the possessor.

A few of the stories related of the Mearnans will illustrate the various phases of this belief. They are given substantially as told by the narrators. Two parties of men were one day at work in the field putting up the hay into reeks, and one party was getting ahead of the other. A man of the slower party called the attention of a comrade named Mearnan to this fact. "Never mind," said Mearnan, "just wait." The others had their reek finished first and were just putting the top on it, when the whole pile fell over, burying the men under it, and Mearnan's party came out ahead.

Another one of the same family stopped one day to admire a fine mare. As he started to go, a neighbor suggested to the owner that Mearnan ought to bless the mare. Much against his will he was compelled to come back, bless the animal and spit upon it. Soon after the mare had two foals, which were both dead, and if he had not blessed the mother she would have died likewise. The same man was one day passing along the road when he stopped to admire a horse in an adjoining field. The next day the animal, in attempting to jump across a ditch, fell into it and could not rise again. The owner and several of the neighbors tried for some time to get the animal upon its feet, without success, until at last one of the men remarked to the owner, "Micky, didn't Mearnan say yesterday that was a fine horse?" "He did," says Micky. "Well, then, you send for him and make him spit on it." So Mearnan was sent for, and whether he liked it or not he had to come. As soon as he laid his hand upon the horse the animal neighed. He said, "God bless you," and spit upon it, and the horse at once climbed up out of the ditch. The owner's wife, who was looking on, said to her husband, "Faith, Micky, if spitting ever got a horse out of the ditch, and it did yours to-day."

A woman of this name caused an accident to her little boy, just learning to walk, on three several occasions, by calling attention to his agility in climbing up on the table or the dresser. Each time he fell down from his elevated position and broke his leg. When this happened the third

* Pronounced, *Gŭ mŏ bawh wawna dhŏ khuj bawh, gŭ mŏ chŏkh er an awrja dhŏ hŏkh, ŏgus gŭ mŏ ban vraw dhŏ van.*

time her brother, who well knew the reason of it, told her that it was her fault, in not having blessed the child when she spoke of it. The mother would not believe it, and insisted as strongly that the brother was responsible for the accident. When the boy grew up he was obliged to wear trousers instead of knee breeches to conceal the deformity caused in this manner. This woman one day met a young man going to church, and carrying his shoes in his hand, as the road was muddy. She made some complimentary remark about his feet, and when the young man got home from church they were turned inward, and he was unable to stand upon them. The woman was sent for and compelled, very unwillingly, to bless his feet and spit upon them, but as she was going out of the door she turned round and said, "May it never thrive with you." The young man recovered the use of his feet, but there was always a twist in them afterward. In this climate a tramp of several miles barefoot over a muddy road, together with kneeling or standing for two hours in a cramped position on the cold floor of a church, might have resulted in rheumatism.

One of the Mearnans was so well aware of this blighting influence in himself, that on entering a house to pay a visit he would always spit upon and bless each member of the family before sitting down.

A number of men, including two carters with their horses, were one day at work in the County Cavan, when one of the party happened to say something in praise of the animals. On quitting work for the day the horses were found to be sick, and soon lay down and were unable to rise. Several remedies were tried without avail, until some one told the owner of one of the horses that the man who had praised them in the morning had an evil eye, and advised him to get him to spit upon them. He said he could not do that, as that man had a grudge against him. His friend then told him to get a piece of the man's clothing and burn it near the horses. That night the carter secretly cut a piece from the coat of the man who was responsible for the trouble, and going out to the horses he set fire to the rag and held it first near the head of his own animal and then near the other. In the morning his horse was well and the one belonging to the other carter was dead. The virtue was gone from the cloth before it reached the second horse. As the one who related the incident said, it was, "Man, save yourself." In this instance the knife used belonged also to the owner of the coat, but this had no effect upon the result.

The Blessed Wells.

In addition to the practitioners of various kinds, the people have great recourse to the numerous "blessed wells" throughout the country. The religious veneration for healing wells is older than history, and is found, not only in Ireland, but throughout Europe and Southern Asia. It is frequently referred to in the Bible, the most notable instance being that of the pool of Bethesda. There seems to be nothing of the kind among our Indians, who, although they regard certain localities with peculiar rever-

ence as the abodes of invisible manitos, to whom they never fail to make some offering in passing, yet apparently do not attach any healing powers to such places.

There are hundreds of these wells in Ireland, at least twenty being in the County Galway alone. They are generally dedicated to some saint, and there is always a legend to account for their origin. Thus Colum-Cille's well, at Kells, in the County Meath, sprang up from the floor of the saint's house while his mother was lying on a sick bed, thirsting for a drink. In many, and perhaps in most cases, ancient Druidic remains or round towers are found near them, showing that these have been places of religious resort even before the dawn of Christianity. Should one of these wells be defiled, it would at once cease to flow, and the perpetrator of the sacrilege would wither away under the curse of the patron saint of the spring. The water must not be used for ordinary purposes. Incidents are related of women, who, being in haste to prepare a meal, have taken water from a blessed well close at hand rather than go to another spring at a distance, but found, after exhausting their patience in fruitless efforts, that it was impossible to bring the water to a boil. This is perfectly true, as the strong mineral impregnations which give the water its medicinal virtues, render it extremely difficult to boil under ordinary circumstances. There is usually a fish, a worm, or a peculiar stone at the bottom of the well, and the circumstances attending its appearance are regarded as omens of success or failure in obtaining relief. On departing from the well, pilgrims leave behind some small token of their visit, generally a shred torn from the clothing, which is twisted into the ivy that clambers up the rock, or hung from the limb of a tree overshadowing the water. These trees may be distinguished afar off by the number of rags suspended from their branches and fluttering in the breeze. This is an ancient custom, and is still practiced in Southern Asia as far east as Ceylon, and throughout Northern Africa, and along the east coast as far south as Zanzibar. Cripples who have recovered the use of their limbs leave also the crutches and litters used in coming. Besides the wells, there are many small lakes and waterfalls which are visited for the same purpose. Many of these wells have been deserted since the great famine of 1847-8.

While religious exercises are a prominent feature at all these resorts, there are some which are visited principally from motives of devotion. Chief among these is the celebrated Lough Dearg, in Donegal, which was resorted to by pilgrims from all parts of Europe during the Middle Ages, and where the rigid discipline imposed upon the penitents in its subterranean caves is said to have served as the model for Dante's Purgatorio. The wells are resorted to for almost every variety of ailment, but there are some which are especially noted for the cure of particular diseases, such as ulcers, sore eyes, or rheumatic affections. The pilgrims frequently come from long distances, sometimes even walking a hundred miles. The exercise, which is known as "making the stations" or "going a round,"

is sometimes performed by proxy, or by the invalid after recovery in accordance with a vow made during his illness. In the latter case, he is generally accompanied by a friend, who goes through the same exercises. The sanitary part consists of immersion, shower baths—where the water falls over a rock—rubbing and drinking the water. The operation is generally repeated on three, sometimes on seven or nine consecutive mornings, while the patient is still fasting. The religious part consists of the repetition of a number of prayers, usually the Our Father and Hail Mary, or the two combined in the rosary. While reciting these prayers the patient walks or is led around the well a certain number of times, always following the course of the sun. The circuit is frequently made upon the knees, and in every case the pilgrimage is undertaken and carried out in a spirit of deep religious fervor.

The wells are visited at all seasons of the year, but the favorite time is the day consecrated to the patron saint of the well. In some cases a remarkable phenomenon takes place at a certain hour, and is awaited by the people as the signal for entering the water. Thus St. John's well, a noted well at Kilcarty, in the County Meath, is visited on St. John's eve—June 23, or midsummer eve, the great fire festival of ancient and modern Ireland. Just at midnight a mist rises from the surface of the water, on seeing which those in waiting begin the circuit around the well. A similar phenomenon is related of Lough Ee-Cinlaan, a small "blessed lough" near Kenmare, in the County Kerry, which is also visited on St. John's eve and the following day. At a certain hour three "tussocks" of floating grass in the middle of the lough begin to move around in a circle, upon which the people waiting on the bank go down into the water. Compare this with the Bible account of the pool of Bethesda, which was surrounded by five porches. "In these lay a great multitude of impotent folk, of blind, halt, withered, waiting for the moving of the water. For an angel went down at a certain season into the pool and troubled the water. Whosoever then first after the troubling of the water stepped in, was made whole of whatsoever disease he had."* In each case the remarkable appearance is doubtless owing to the same causes which govern the periodic movements of geysers and other intermittent springs.

In the lough just mentioned, one of the three tussocks always moves around in the rear of the other two, which, like everything else in Ireland, is accounted for by a legend. They formerly moved along abreast, until one day a sacrilegious wretch attempted to mow the grass for his own use. The moment he struck his scythe into the first tussock, blood followed, as from a living thing, and dyed the waters of the lake. Terrified at the sight, he desisted from his purpose, but ever since the wounded tussock has limped behind its fellows.

A brief extract from a recent Irish letter, written in reply to some questions concerning the blessed wells of the County Galway, will give a

* John v: 3, 4.

better idea of the present beliefs and practices in this connection than many pages o description. The writer is one of the people, and has been familiar all his life with the customs which he describes so accurately. The extract is given in his own words, with the exception of a few slight grammatic changes. The letter is written from Curnamona, near Clonbur, about twenty miles north-west from the town of Galway:

"Thubber Muira and Feheen, in Ballintubber. Noted to cure any kind of sickness that may occur in a family. Station days are the eve of any of the Lady Days—eighth of September, fifteenth of August and second of February. The stations are performed thus:

"The person will kneel before the wells barefooted, will say so many prayers, and will take in his right hand seven pebbles, of stones which are for the purpose at the mouths of the wells. After walking around the well he will drop a pebble at each round, will kneel again and say more prayers, and so on until finished. There is one remarkable thing about these wells. After promising a station at these wells, if a person goes and prays there, he will see a small worm; and if the worm lives (*i. e.*, is alive) the patient will recover, and if seen dead the patient will die. After performing a station here, if it be a male person he will drop a button in the well, sometimes a piece of coin, etc.; and if it be a female, she will pull some threads out of her shawl or some part of her clothes, which she ties on the bush that covers these wells. Persons abroad promise stations at these wells and get some of their friends on this side to perform them, which must be done by two persons together."

In this instance there are two wells at the same locality. The name of the principal one, Thubber Muira,* or "Mary's well," shows that it is dedicated to the Blessed Virgin, and consequently the favorite times for visiting it are the "Lady Days," or days specially devoted to her honor. These are named in the order of their importance, which is the reverse of the chronologic order. Feheen† is the name of a saint of local celebrity, and is sometimes rendered by Festus. It is to be noted that the name of the place, Ballintubber,‡ signifies the "town of the well," showing that the village owes its name, and perhaps also its origin in the remote past, to the presence of the spring in its vicinity. The water is probably used as previously stated, according to the nature of the complaint.

A second extract from the same letter furnishes an excellent illustration of some of the beliefs connected with these wells, aside from their healing powers. After describing Thubber Enue, or Eneas' well, which springs out of a rock in the hill of Doon, in the same region, and is especially noted for the cure of sore eyes, the writer goes on to say, "There was another remarkable affair about this well—a kind of a round stone, called

* Gaelic, *Tobar Muire*. The three wells and the *leac* described in this letter are also noticed in Wilde's Lough Corrib, already referred to, pages 267-9.

† Gaelic, *Fec'in*.

‡ Gaelic, *Baile'n-Tobair*.

*Lyoc Enue.** Prayers were offered and this *lyoc* turned over. For instance, if one person belied another, or gave scandal by any means, then the person would go and offer those prayers and turn the *lyoc*, and whosoever of them would be in the fault, he was sure to die; but whatever time of the year this would occur, it was sure to be followed by bad weather, thunder and rain. So the farming class was almost ruined by this work, and the people practicing it more and more, until at last the clergy got the *lyoc* taken away and thrown into the deepest spot of Lough Corrib—and more was the pity, for the people were not so often at that time going to petty sessions as they do now; they were leaving it all to God and *Lyoc Enue*."

In another letter, dated January 20, 1887, the same writer thus mentions a noted waterfall in the same neighborhood: "There is a waterfall convenient to this place that cures pains of the back. The patient goes in his or her nakedness, for about ten minutes, under this waterfall, and the third time is sure of being all right. The only thing given down for this is, that a priest in the time of *Shawn-na-Soggarth*† was concealed for twenty-four hours under this waterfall." Whatever may be thought of the theory in this instance, it is plain that the treatment is exactly that adopted by the best surgeons in dealing with sprains and similar ailments, including "pains of the back," viz., subjecting the affected part to the action of a stream of cold water falling from a considerable elevation.

The pool of Bethesda at Jerusalem has already been noticed in this connection, and a comparison of the present Irish beliefs and customs in this regard with the Bible story of Naaman will show that they are substantially those which existed among the Jews nearly three thousand years ago. Naaman was a Syrian general, living at Damascus. He was afflicted with leprosy, and at last, by the advice of his friends, undertook a long journey to Samaria to procure the help of the prophet Elisha. When he had reached the latter city, "Elisha sent a messenger unto him, saying, Go and wash in Jordan seven times, and thy flesh shall come again to thee and thou shalt be clean. * * * Then went he down and dipped himself seven times in Jordan, according to the saying of the man of God; and his flesh came again, like unto the flesh of a little child, and he was clean."‡ In this case the Syrian practice seems to have been different from that of the Jews, as Naaman had expected that the prophet would cure him by simply touching the diseased part and invoking the name of his God.

There can be no doubt that these "blessed wells" of Ireland are mineral springs of great medicinal virtues, as the whole country is a mineral region, containing coal and iron in abundance, with limestone cliffs along

*Gaelic, *Leac Aong'us* "Eneas rock, or slab."

†Gaelic, *Seag'an na Sagart*, "John of the Priests;" the name given by the people to a "priest hunter" during the time of the penal laws.

‡2d Kings v: 10, 14.

the western coast, while the alluvial soil is deposited upon a stratum of turf or peat, which crops out at intervals in the numerous bogs. We should thus expect to find in these wells the same constituents that give a reputation to the mineral springs of the mountain region of Virginia and Pennsylvania. According to Dr. John Rutty, the author of two valuable works* on the mineral springs of Ireland and of Europe in general, some of the Irish wells commonly resorted to by the people are equal to any of the celebrated continental spas, while those noted for the cure of particular diseases contain just the constituents most beneficial in such cases. The ordinary impregnations are combinations of iron, lime, soda, magnesia and sulphur. In addition to these, many wells and streams are impregnated with petroleum and bituminous compounds, owing to their vicinity to the bogs, which contain large quantities of half-fossilized pines and other resinous conifers. It is a well-known fact that bog water has preservative qualities, and bodies of persons drowned in these bogs have been recovered long afterward still undecayed. There are also some streams and lakes, notably Lough Neagh, whose waters have petrifying properties. Were Ireland free to develop her own resources, not only would her neglected mines and marble quarries be made available, but her healing springs, now visited only by barefooted peasants, would speedily acquire a reputation, which, together with the natural beauties of the country, would attract thousands of those who yearly seek health or pleasure on the continent. There is nothing but simple truth in the proud boast of the people of Ireland that in their native country the grass is always green, the soil harbors no venomous reptile, and the waters are blessed.

Miscellaneous Charms.

Besides the blessed wells and the *sig·efreog*, the people have a number of charms for various diseases—in fact, it is probably safe to say that they have a charm for every malady, real or imaginary, that ever existed. Many of these charms are accompanied by verses or other formulas, which have been handed down for generations, and there is generally a legend to explain the formula. A few of these charms are here given. It must be stated at the outset that the application is always made in the name of the Father, Son and Holy Ghost. Should any one become sick in church while wearing a garment sewn on Sunday, it will be impossible to cure him.

Epilepsy is called *tinneas mor*,† the "great sickness," and is regarded with such dread that it is seldom mentioned except under some figurative name. The patient is cured by drinking milk boiled in a human skull. An "essence" prepared from a human skull was formerly used in Italy to cure the same disease, according to a medical work published in that

* A Methodical Synopsis of Mineral Waters, &c., and Essay Towards a Natural, Experimental and Medicinal History of the Mineral Waters of Ireland.

† Pronounced *chinyas moer*.

country in 1726, and the skull of one who had died a violent death was preferred, being considered to retain more of the vital principle.

Toothache is cured by rubbing the gum with the finger of a corpse, or washing it with some of the water used in washing the corpse when preparing it for burial. The cure is permanent. The pain is commonly supposed to be caused by a small worm eating the tooth, and this worm is sometimes killed by applying to the tooth a piece of tobacco, guano, or some other pungent substance. The Omaha Indians, who hold the same theory, kill the worm by blistering the skin on the outer surface of the jaw. The dead hand holds an important place in Irish mythology.

Headache is called *fiab'ras beag*,* or "little fever," and is caused by the joints of the skull springing apart until "the head is open"—just as we sometimes hear a man under such circumstances say that his head is splitting. The woman who has the cure takes a woolen string, with which she measures the head of the sufferer in three different directions, in order to see how far it is open. First the string is put under the chin, and the ends are brought up over the top of the head. Next it is measured in the same way from under the nose to the back of the head, bringing the ends of the string across just above the ears, and finally the string is drawn around the forehead and over the temples to the back of the head. Having learned how much the head has opened, she presses it firmly between her hands to bring the sutures together, says certain words, and the cure is effected. In one instance the patient was told that his head had opened something more than an inch. There may be more virtue in this method than is at first apparent.

Earache is cured by putting into the ear a piece of wool from a black sheep, saturated with oil, at the same time reciting the appropriate words. The last remark holds good also of this cure.

Sore throat is cured by putting the head of a live gander into the mouth of the patient and making it scream down his throat. The *thrush* in children is cured in a similar way, by getting a posthumous child to blow into the mouth of the sufferer. The blowing must be done by the operator while still fasting, and is generally repeated for three successive mornings.

Some persons can "set a charm" to *staunch a wound* so that not a drop of blood shall flow from it. The charm is said to consist solely in the repetition of certain words, without any application whatever. A hemorrhage can be stopped instantly by the application of a garment, which has been washed or ironed on Sunday.

There are several cures for a *sprain*. The most common method is to tie around the joint a *fogee*, or worn-out thread from a loom. Sometimes a string is used which has been held in the mouth while a certain charm is recited. The most remarkable method is used in Kerry, both for men

* Pronounced *fevearas b'yug*.

and animals, and is here given without comment, as described by a man who saw the operation performed at his own house for the cure of a lame horse, which recovered before morning. There is a thorny shrub, known in that county as *sgeac'-m'adera*,* or "dog briar," whose white flowers are fixed close to the stem, while its thorns point downward. As our Savior, when a child, was one day walking with His mother, they met this briar and admired its flowers. The Mother tried to pluck one of them, but could not reach it until the briar bent down to her grasp. Since then its thorns always bend downward. To perform the cure a rod about three feet long is cut from the *sgeac'-m'adera* and split down the middle. Two men then stand close together, facing each other, each one holding against his body, at the right and left side, one end of the two pieces thus made, while his companion holds the other two ends in the same manner. In a short time the two rods begin to bend in toward the centre and gradually approach each other until they are firmly united for about six inches of their length in the middle. The man who sets the charm—a third party—then cuts off this portion and lays it upon the sprained joint, repeating certain words at the same time. The rest of the stick is thrown away. This charm never fails, excepting when there is a stain upon the birth of one of those holding the rods.

Scrofula, or the *evil*, is sometimes cured by applying a little powder from a deer's horn, which is kept in houses for this purpose. Another common method is to apply the blood of nine or twelve young wrens. The number must be decided by the ornithologist, as they take the whole brood, which, according to some persons, always consists of twelve birds, while others say there are only nine. This blood is called *fuil rig'e*† or "king's blood," for the wren is the king of birds in Ireland as in Germany. There may be some connection between king's blood and king's evil. The water of St. John's well, already referred to, is also noted for curing this disease.

The cure for *sore eyes* due to the presence of some foreign body, is best described by an incident, given as related by the man who was cured by the operation. While gathering seaweed on the strand he got something in his eye, and sent instructions to a *bean feasac'* living six miles away to take it out. She put some clean water in a glass, took it in her mouth, repeated a charm known as *aroid a b'raoinin*,‡ the "charm of the little drop," and then squirted the water back into the glass. The obstruction was seen floating on top of the water, and the woman took it out and threw it away. At the same instant the man working on the seashore experienced relief. This reminds one forcibly of the orthodox Indian medicine man.

A man who found a cataract growing over his eye walked on three suc-

* Pronounced in Kerry *shg'yökh-wödhera*.

† Pronounced *fwil ree*.

‡ Pronounced, *ôroej a wreeneen*.

cessive mornings before breakfast to the house of the woman who cured it, which she did by making the sign of the cross upon his eye with her finger three times on each occasion, repeating a charm at the same time. If a bramble, or the finger, should accidentally strike the eye, the pain is at once relieved by making the sign of the cross in the same way three times with the object which caused the injury.

There are several cures for *rheumatism*. One, which has its parallel in this country, is to carry a potato in the pocket, and as the potato dries up the patient will recover. Another way is for the patient to lie upon his breast, and let a man who came into the world feet foremost walk along his body from the feet to the head. In one instance, where a man was completely crippled by rheumatism in his knee, he was advised by a woman to make a poultice of raw potatoes sliced very thin, and bind it upon his knee, and keep it there without change until the potatoes became offensive from decay. He did as directed, and after wearing the poultice for several weeks until he could endure the smell no longer, he found himself recovering. The potato is believed to have great medicinal virtue, as is also the water in which potatoes have been boiled.

A man who suffered from *colic* applied to another who had a cure for it, and was given a small piece of unsalted butter, with instructions to take a little of it for three consecutive mornings, while still fasting, reciting certain prayers at the same time. He could not say positively what those prayers were, "for fear of telling a lie." The doctor was not allowed to take pay for his cure, but might accept a free gift. The man did as directed, and was permanently cured, nor did the butter ever melt or become less, although he kept it until he was coming to America. Another man on the vessel was troubled in the same way. He lent him the butter, and it cured him, but on looking for it the next morning it had disappeared. Unsalted butter is used in a great many charms, and may not be such a bad thing after all.

The following charm for *tumors* and similar swellings comes from Meath. The patient, a child who was afflicted with an unnatural swelling just above the upper lip, on three consecutive Friday afternoons walked several miles into Navan, so as to arrive at the house of the *bean feasac* just as the sun was setting in the west. Turning the child's face toward the setting sun, the woman bathed the swelling with a liquid from a glass which she held in her hand, repeating certain words at the same time. After the third Friday the swelling disappeared. This idea in connection with the setting sun is part of an old belief common to all Europe, which prompts farmers to plant crops with a growing moon, and leads fishermen to expect the end of a dying man when the tide is going out. It is impossible to learn the composition of the liquid.

Warts are cured in the same county by impaling a snail upon a hedge thorn. As the body of the snail shrivels up, the wart disappears. The

idea here is similar to that just mentioned. In Connamara for the same trouble ten joints (the knots only) are cut from an oat stalk, nine of which are tied up in a small parcel, while the tenth is thrown away. The parcel is left at the cross-roads, and the warts will go to the one who picks it up. The idea here is also common in European folk-lore, and almost the same method is used in Switzerland. The selection of ten similar objects, one of which is afterward thrown away, appears also in the account already given of the child cured of convulsions. It is also proper to mention here that oats are the sacred grain in Irish mythology.

Another method is, on rising in the morning, to spit upon the hearth while still fasting, and then rub the spittle upon the wart with the second finger. The first finger is never used for rubbing spittle or ointment upon sores of any kind, as it is supposed to have a poisonous effect. The operation is repeated every morning until the wart disappears.

Another method, used in Galway, is to bathe the wart with water found lying in a depression in the surface of a rock, saying at the same time:

"*Uisge cloc'a gan iarraid',*
Ni'g t'iarraid' tá me."*

"Water of a stone without seeking,
It's not seeking for you I am."

As the words of the formula imply, the water must be found accidentally, no benefit resulting from its application when a deliberate search is made for it.

In a case resembling *asthma*, where the patient, a boy about seven years old, felt a constant choking sensation and was rapidly losing flesh, he was taken by the old man who had the cure, and placed standing with his back against a tree growing in a field—the tree, in this instance, being an apple tree. A hole was then bored in the tree just above the child's head, a lock of his hair cut off and placed in it, and the opening closed up again. Although not mentioned by the informant, some words were undoubtedly repeated at the same time. As the boy grew above the hole in the tree, he grew away from the disease.

A well-known charm used in cases of *decline*, or incipient consumption, may be described by giving an instance, without comment, as related by an eye-witness. A young girl of lively disposition suddenly lost health and spirits, and appeared to be rapidly sinking into the grave, when her friends persuaded her to visit an old woman who offered to cure her. On arriving there the woman filled a tumbler with oatmeal, even with the top, and wrapped a thin cloth around it. Then loosening the girl's dress she applied the mouth of the tumbler first to her back, then to her side, and lastly to her bosom. On removing the cloth from the tumbler it was found that half the meal had disappeared. The glass was refilled and the

* Pronounced, *Ishga clūkha gun eerree,*
Nee gā cheerree thaw mac.

operation repeated, and on removing the cloth a part of the meal was gone, but not so much as the first time. Once more the tumbler was filled and applied as before, and this time, on removing the cloth, there was hardly a depression in the surface of the meal, and the woman pronounced the cure complete. The girl's friend, who had looked on with wonder, now asked what had become of the meal. The woman replied, "I gave that to the worms that were eating her heart." In some cases the three operations are repeated on as many consecutive days.

For *worms* an amulet is worn, which consists of a small piece of paper on which is written a charm. The *bean feasac'*, holding this paper in her hand, kneels down and recites a prayer, and the paper is then sewn into a covering of red woolen (flannel) cloth, of three-cornered shape, and worn about the neck.

Cramp is caused by worms, which twist themselves into a knot about the intestines. For this trouble, in men or animals, a string is tied with a peculiar triple knot, known as *snaid'm na peiste*,* or "the worm's knot," in such a manner that on pulling the ends of the string the knot is undone. The sufferer is struck on the stomach or back several times with the string, before and after knotting it, the name of the Trinity being invoked at each blow. In Kerry it is merely placed upon the stomach of the patient, and the ends pulled so as to undo the knot. Any one subject to cramps will be cured by making the sign of the cross three times on his stomach on seeing a rainbow.

For *convulsions* in children it is sometimes customary in the County Galway to use a preparation of charcoal made by burning and pulverizing the bones of an infant which has died before baptism.

Boils, however swollen and painful, may be cured by a blacksmith who is the seventh son of a blacksmith. It is only necessary that he shall open and shut his tongs three times in front of the boil, without touching it. The seventh son has generally great power over disease.

The *ringworm* is called *teine-d'iad'a*,† or the "divine fire," and is cured in a number of ways. Perhaps the most common method is to rub the inflamed spot three times with a ring or other article of gold, or with a live coal of fire, saying at the same time, *O'ugat || a teine, || a t'eine-d'iad'a.*‡ "Beware of the fire, *teine-d'iad'a*," the gold or coal of fire being applied as each of the principal words is being pronounced. The operation is repeated three times, making nine applications in all. Another method is to apply the blood of a black cat, and in some houses there are cats whose ears have been cut away by piecemeal for this purpose. Black and red (the color of fire) are the principal colors of Irish mythology. Another method is to write around the ringworm the full name of the sufferer,

* Pronounced *sneem na paeshcha.*

† Pronounced *chinnee-yea.*

‡ Pronounced *hügath a chinnee, a hinnee-yea.*

while still another is to rub the spot with spittle upon the second finger for three successive mornings.

The *black tongue* in cattle is called *bolg-t'eanga*,* or "swelled tongue," and is sometimes cured by bleeding the animal in the tail, but more often by reciting the following charm, by means of which the Blessed Virgin, while one day walking with her Son, cured the cow of a poor widow, who was unable to give them a drink of milk on account of the illness of the animal:

"'N aroid a c'uir Muire go b'o C'ual-an-daire,
O feid' a druime go feid' a siorra;
Air b'uinn, air c'enn, air b'o-g'éimneac', air g'alra truad',
Agus air leig'eas na bolg-t'eanga." †

Cual-an-daire, which is evidently a compound word, is explained as the name of the village where the widow lived, while *buinn* and *cenn* appear to be the names of two cattle diseases. The Gaelic may be thus rendered:

"The charm which Mary put on the cow of Cual-an-dherra,
From the sinew of her back to the sinew of her pastern,
For *bûinn*, for *cenn*, for the groaning cow, for the wasting sickness,
And for a cure of the swelled tongue."

There is another contagious cattle disease, which generally attacks young animals of the best breeds, and is known in the Gaelic districts as *ceat'ram'a-d'ub'*,‡ the "black quarter," and elsewhere as black-leg or quarter-ail. It begins with a slight lameness in one of the quarters, which soon swells and becomes discolored, and in a very short time the animal dies, the instances of recovery being extremely rare. In Kerry, as soon as the animal is dead, the affected quarter is cut off and hung up in the chimney, in the belief that this will prevent the spread of the contagion. As the infection may be communicated to the other cattle by smelling the diseased part, and as there is always danger that the buried carcass may be rooted up by hogs or dogs, there seems to be something in this method to recommend it.

Any one who licks a lizard three times along the under side from the tail to the head can cure a *burn* by applying his tongue to the injured part three or nine times. This may have some connection with the old salamander theory. In Galway, on receiving an accidental burn, it is customary to ejaculate: *Lab'ras easbal agus Dia d'a f'reastail*,§ "Lawrence, the apostle (*sic*) and God to care for it." In Meath they exclaim, *Morra*

* Pronounced *bûlag-honga*.

† Pronounced:

'Nôroej a khûir Mâira gō woe Khual-an-dherra,
O fae a dhrûma gō fae a sherra,
Er win, er khen, er woe-yaemnakh, er ghawlra thrua,
Ôgus er l'yice na bûlag-honga.

‡ Pronounced in Kerry *carhoo-ghoov*.

§ Pronounced *Lowaras asbal ōgus jea ghaw rasthal*.

PROC. AMER. PHILOS. SOC. XXIV. 125. U. PRINTED JUNE 4, 1887.

sneef, which is probably a corruption of *Maire 's naom·t·a*,* "Most Holy Mary!"

When the *palate falls* it is raised by lifting the skin at a certain point at the back of the head. A similar method is used by the negroes.

Hooping cough is called *troc·*† by the Gaelic speakers, and *chin-cough* in the eastern districts, and there are a number of charms for it. One used in the south is to pass the sufferer three times over and under the body of a donkey, in the name of the Trinity. The same thing is done in Scotland. Sometimes a piece of bread or something of that kind is given to the donkey to eat, and the crumbs which he lets fall to the ground are put into broth for the patient. The most remarkable method is adopted in Galway, where the mother of the child goes to the owner of a white horse and asks:

"G·iol' an eac· g·eal,
Cé rud a leig·eas air a troc·?‡

"Fellow of the white horse,
What thing is the cure for the whooping cough?"

He generally replies, "A cup of tea and a piece of bread," or something of the kind, and whatever he advises is given to the child in the confident hope of relieving it. The words used in asking this question are important, as showing the antiquity of the charm. The ordinary form for "white horse" is *capal bán*,§ while *eac·* is an obsolete word, and such an expression as *eac· geal* is found only in the ancient manuscripts and in poems and stories and similar compositions which have been handed down from a remote period.

The donkey is also in great repute for curing almost any contagious fever, as typhoid fever, etc. If the patient be a child, the donkey—a young one being preferred—is lifted three times over his head from front to back, after which the sick person drinks some of the milk of the dam. If the invalid be an adult, and sufficiently strong, he takes the animal by the fore and hind feet and lifts it over himself in the same manner. The donkey, or ass, is regarded as sacred, on account of being the animal upon which the Saviour once rode. The black cross upon his back, formed by the intersection of two lines of dark hair near the shoulders, is supposed to commemorate this event, and a young animal is preferred in these charms on account of the greater distinctness of the mark in the foal. It is considered lucky to have a donkey about the house, and many farmers who own horses, and have no need of donkeys, keep one in the field for this reason. A similar belief in regard to the sacredness of the donkey,

* Pronounced *Morra 'sneeva*; in the vocative the sound becomes *Worra*.

† Pronounced *thrūkh*.

ronounced, *Yil' an yōkh yal,*
Cuer' dh a l'yice er a thrūkh!

‡ Pronounced *cŏpal bawn*; *capal* is the Latin *caballus*, while *eac·* is equivalant to *equus*.

and its usefulness in the cure of certain diseases, especially whooping cough, prevails also in England and Scotland.

There is a disease, called *cleid'in** in Gaelic, which is difficult to characterize, but is described as a general break down or loss of strength, resulting from some sudden and violent over-exertion. In lifting heavy weights it sometimes happens that what is known in the eastern districts as the "spool of the heart"—probably the diaphragm from the description—is torn loose and drops down, so as to press upon the intestines. When this occurs the spool of the heart must be raised again, which is done in the following manner: A coin is stuck upon the lower end of a short piece of candle, which is then lighted and placed upright upon the bare breast of the patient, who, of course, is lying down. A tumbler is then inverted over the lighted candle, and in a few moments the skin over the inclosed surface is raised up into a blister and the sufferer finds relief. It is hardly necessary to state that this is simply a crude cupping process. This method is known throughout the country, but it is a disputed point whether the coin should be a copper ha'penny or a silver sixpence. The disease bears a different name in the south.

Erysipelas is called *ruaid'*,† which signifies something red, by the Gaelic speakers, while in the east it is known as *rose*, or *St. Anthony's fire*. It is generally cured by means of a charm used in connection with the *dearg-liac'*.‡ This is a grassy plant growing in the bogs, and having the lower part of its stems of a bright red color, by reason of the bog water with which they are always covered. The fact that it is sometimes used by laborers as a substitute for soap, shows that it possesses some peculiar properties. The operator—who should be a woman if the patient be a man, or a man if the contrary be the case—gathers a considerable quantity of this grass, holds it up in front of the mouth and breathes upon it, at the same time reciting a certain charm, after which it is bound tightly around the inflamed part. This must be done on the next Monday after the disease first appears, and is repeated "*d'a Luain agus Dia-d'ardaoin eadorra*,"§ that is, "two Mondays and Thursday between them," making three applications in all. The sufferer must endure the pain until Monday comes round, and it is also essential that the three applications be made under the same moon in which the illness is first noted, otherwise the trouble will be liable to recur every month afterward. Unsalted butter is sometimes used instead of the *dearg-liac'*, but is not considered so good, although the charm is recited in the same way. If a sick person should overhear his friends say that he has the *ruaid'*, he would at once be obliged to undergo the operation, no matter what might be the nature of

* Pronounced *clá-een*.

† Pronounced, *rua*, or *ruee*.

‡ Pronounced *jărag-leeakh*; perhaps from *dearg*, "scarlet," and *liac'*, "gray," the *dearg* referring to the discoloration of the stems.

§ Pronounced *ghaw Luan ŏgus Jaerdheen ădharra*.

his illness, under the certain penalty of taking the disease if he neglected the precaution. For this reason his relatives are careful not to "accuse" him of this disease unless the fact is beyond question. Stripped of all mythologic embellishments, there seems no reason to doubt the existence of some curative property in the *dearg-liac'*, as numerous instances are related of its efficacy.

A stitch in the side is cured by applying the blood of a rooster which has been sacrificed to St. Martin. On the eve of St. Martin it is customary to sacrifice an animal to the saint, or, as the people express it, they "draw blood for St. Martin." The animal most commonly selected is a rooster, which has been consecrated to this purpose some time in advance. The blood is soaked up with tow or cotton, and preserved as a remedy for the stitch. At the moment of applying it to the side of the sufferer the following words are recited:

"Fear caoin aig a mnaoi b'oirb',
A c'uir Iosa Criosd na luig'e anns a g-colg;
C'uig m'euraib' Iosa Criosd fuascailt do g'reime,
Dearna M'uire agus a Mic leat." *

Which may be thus rendered:

A mild man with the haughty wife,
Who put Jesus Christ lying on the hulls (of the tow);
The five fingers of Jesus Christ to relieve your stitch;
The palm (of the hand) of Mary and of her Son with you.

In Galway the form is somewhat different, and the characters of the man and his wife are reversed. In the same county the blood is sometimes sprinkled upon the different members of the family when the animal is killed, and the words alone are used to cure the stitch, as well as a stomach ache. The words are founded on the legend that Christ once asked permission to stop over night at a house, where the husband, a kind-hearted man, was disposed to accommodate him, but his wife, who was of the opposite disposition, compelled the Savior to sleep on the hulls stripped from the flax. For this reason tow is preferred to cotton. The practice is known throughout the country.

One more instance and we have done. In this case the informant was ignorant of the words which were undoubtedly used, and we have left the simple statement of the medical treatment and its result. The son of well-to do parents in the County Kerry was so crippled by a painful swelling of the leg that he had to be taken to Tralee for treatment. The doctors held a consultation and decided that the limb must be amputated. At this juncture a "traveling woman" from the north—where the people are supposed to have most knowledge in such matters—called on the

* Pronounced, in Kerry: *Fuur cēen ig a mnee wūrav,*
A khēir Esa Oreesdh na lee ans a gēlag;
Khuig vaeriv Esa Oreesdh fuascalth dhō ghrēma,
Javerna Wirra ōgus a Mic lath.

father of the young man and asked permission to try her skill. The doctors objected, but the father said that as they had done their best to no purpose, she could do no worse. Having obtained permission, she went out and gathered a quantity of the herb known as *uarac'-a-loc'*,* which she put into water and boiled to a poultice. This was in the middle of the afternoon. She then put the poultice upon the swollen limb, and had the young man tied down to the bed so that he could move neither hand nor foot. In a few hours the poultice began to cause him such terrible agony that, if he had not been so securely fastened down to the bed, the efforts of several men would be required to hold him. This continued for some time, after which the sufferer fell into a sound sleep, which lasted all night. When he woke up in the morning he called out to his father that the poultice had come off. On going to his bedside it was found that the limb had resumed its natural size, which was the cause of the poultice falling off. The young man was able to start home in a short time, and was so overjoyed at his recovery that he walked the entire distance, twelve miles. The cure created a sensation in the vicinity at the time. The herb used is common in pastures and is eaten by cattle with great relish. Its leaves are about an inch across at the base, and from six to ten inches long, and are distinguished by having a semi-circle taken out from one side, which is popularly known as *greim a diab'ail*,† "the devil's bit."

Corresponding Belief in Scotland.

It is an established fact that the ancient connection of cognate nations may be traced in their mythology, even though the people themselves have been separated for ages. This is strikingly true of the Gaelic race of Ireland and the Scottish Highlands. They are still one people, speaking the same language, with but slight dialectic differences, although their fortunes have been widely separated for nearly fifteen centuries, while their customs and beliefs are in a great measure identical. Compare the following cures given by Rev. W. Gregor in an article on "The Healing Art in the North of Scotland in the Olden Time," (in the Journal of the Anthropological Institute of Great Britain and Ireland, Vol. iii, 1874.) The coincidence is the more striking as the article had not come to the notice of the writer until the rest of the paper was in type, and consequently no questions could be asked to draw out parallel customs:

Hooping Cough: "Let the first man seen riding on a white horse be asked what is the cure. Whatever he says, is the cure.

"Let the patient be passed three times below the belly of a piebald horse.

"The milk of an ass was an effectual remedy. * * *

"The patient was held below the animal's head, so as to inhale its

* Pronounced, in Kerry, *oorakh-a lākh;* the word appears to be a compound.

† Pronounced, in Kerry, *greem a jeeal.*

breath. When this inhalation of breath had been carried on for a considerable time the patient was passed three times under the belly and over the back of the brute."

Ringworm: "The common cure for this disease was rubbing with silver. The modes of rubbing were various."

Warts: "Wrap up in a parcel as many grains of barley as there are warts, and lay it on the public road. Whoever finds and opens it inherits the warts.

"Rub the warts with a piece of raw meat, bury it, and as it decays the warts disappear.

"Wash the warts with water that has collected in the hollow parts of a *layer-stone.*"

Eye Disease: "Catch a live frog and lick the frog's eyes with the tongue. The person who does so has only to lick with the tongue any diseased eye, and a cure is effected." Compare this with the cure for burns.

Rheumatism: "Those who were born with their feet first possessed great power to heal all kinds of sprains, lumbago and rheumatism, either by rubbing the affected part or by trampling on it. The greater virtue lay in the feet."

On the Henry Draper Memorial Photographs of Stellar Spectra. By George F. Barker.

(*Read before the American Philosophical Society, April 1, 1887.*)

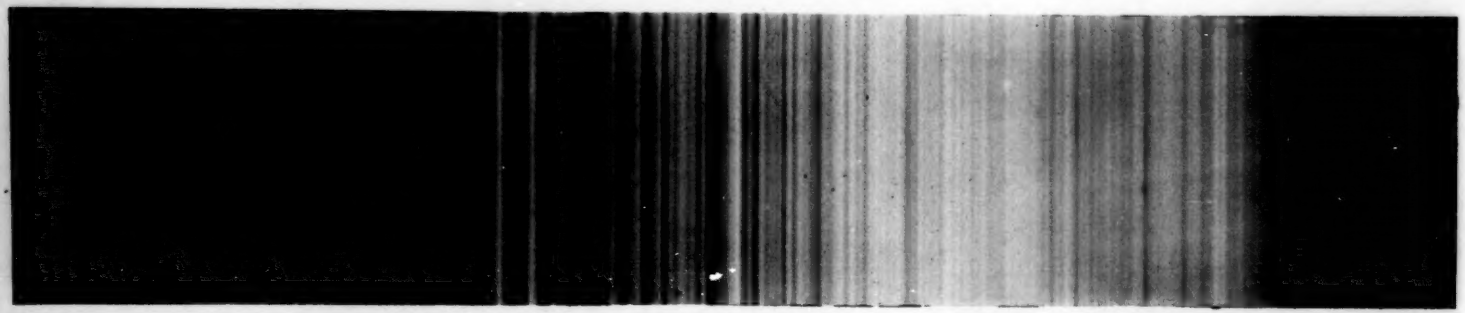
By the courtesy of Prof. Edward C. Pickering, Director of the Harvard College Observatory, I have the pleasure of exhibiting to the members of the American Philosophical Society some of the remarkable photographs of stellar spectra which have been recently taken under his direction, and which form part of an original research to be called the Henry Draper Memorial.

The first photograph of a stellar spectrum ever taken was that of the star Sirius (*a* Canis majoris), obtained by Dr. Huggins in 1863. But, as he says, it was scarcely more than a stain on the plate, and showed no indications of fixed lines.* The first spectrum photograph showing distinct lines, was obtained by Dr. Henry Draper in 1872. The star photographed was Vega (*a* Lyræ), and the spectrum showed four strong lines toward the more refrangible end. It was taken with the twenty-eight inch reflecting telescope which Dr. Draper had himself constructed. Subsequently he used for this purpose the twelve inch refractor which he had obtained from A. Clark & Sons in 1875. Up to the year 1877, he had taken, beside *a* Lyræ, the spectra of *a* Aquilæ, Arcturus, Capella, the moon, Venus, Mars and Jupiter.† In 1880 this refractor was exchanged for another, also

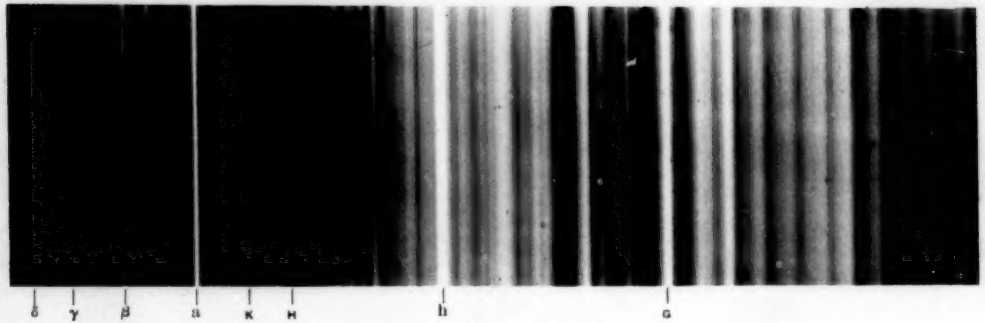
* Phil. Trans., 1864, 428.

† Am. J. Sci., III, xviii, 419, 1879.

HENRY DRAPER MEMORIAL.



α TAURI. 2 PRISMS.



o CETI. 1 PRISM.

made by the Clarks, but which, although of slightly less aperture—half an inch—was provided with a photographic correcting lens. The large amount of work done with these instruments appears from the fact that at the time of his death in 1882, he had taken more than a hundred stellar spectrum photographs, the later ones having a comparison spectrum upon the same plate. The methods employed both by Dr. Huggins and by Dr. Draper in all their later work were in general the same. The light of the star was concentrated by the object glass of a large telescope upon the slit of a spectroscope placed at its focus. In consequence, a narrow slit was necessary in order to obtain good definition, and very perfect adjustment of the driving clock was required to keep the image of the star upon the slit. The spectra thus obtained were of course quite minute; being about half an inch only in length, and only one sixteenth or thereabouts in width. Dr. Huggins made use of a cylindrical lens placed in front of the slit to obtain the necessary width to the spectrum. But Dr. Draper secured this end by throwing the image of the star slightly out of focus.

The first attempts to obtain photographs of stellar spectra which were made at the Harvard College Observatory were undertaken in May, 1885, by the aid of an appropriation from the Rumford fund of the American Academy of Arts and Sciences. In these experiments an entirely new photographic method was adopted. The prism was placed in front of the object glass of the telescope; a plan originally suggested for eye observations by Fraunhofer in 1823* and employed subsequently, practically, by Secchi and Respighi. The advantages, for photographic purposes, of this method are two-fold: First, the loss of light is extremely small; and second, the stars over the entire field of the telescope will impress their spectra upon the plate. Hence while previous observers could photograph but one star at a time, and this satisfactorily only with stars of the first or second magnitude, more than one hundred spectra have now been simultaneously obtained on a single plate, many of them of stars no brighter than the seventh or eighth magnitude. The earliest photographs obtained at the Observatory were taken by placing a prism whose refracting angle was 30° in front of a Voigtländer photographic lens of two inches aperture and about seven inches focal length. No clock-work was used, the spectra being formed of the trails of the stars. In the spectrum of the Pole-star thus taken, over a dozen lines could be counted; and in the spectra of α Lyræ and α Aquilæ, the characteristic lines were shown, even when the time of exposure was only two or three minutes.

In the autumn of 1885, an appropriation was made from the Bache fund of the National Academy of Sciences for the purpose of continuing these investigations. A prism of 15° refracting angle and eight inches in clear aperture was employed, placed in front of a Voigtländer photographic lens having an aperture of eight inches and a focal length of about forty-five inches. The details of the method are thus described in the report of Prof. Pickering:†

* See Schellen's Spectrum Analysis, English ed., 1872, p. 462, et seq.

† Memoirs Am. Acad. Arts and Sci., xi, 209, 1886.

"The prism was always placed with its edges horizontal when the telescope was in the meridian. The spectrum then extended north and south. If clock-work was attached, a line of light would be formed, too narrow to show the lines of the spectrum satisfactorily. The usual method of removing this difficulty is the employment of a cylindrical lens to widen the spectrum; but if the clock-work is disconnected, the motion of the star will produce the same effect. Unless the star is very bright, the motion will, however, be so great that the spectrum will be too faint. It is only necessary to vary the rate of the clock in order to give any desired width to the spectrum. A width of about one millimeter is needed to show the fainter lines. This distance would be traversed by an equatorial star in about twelve seconds. The longest time that it is ordinarily convenient to expose a plate is about an hour. If then the clock is made to gain or lose twelve seconds an hour, it will have the rate best suited for the spectra of the faintest stars. A mean time clock loses about ten seconds an hour. It is only necessary to substitute a mean time clock for the sidereal clock to produce the required rate. It was found more convenient, however, to have an auxiliary clock whose rate could be altered at will by inserting stops of various lengths under the bob of the pendulum. One of these made it gain twelve seconds in about five minutes, the other produced the same gain in an hour. The velocity of the image upon the plate when the clock is detached could thus be reduced thirty or three hundred and sixty times. This corresponds to a difference of 3.7 and 6.1 magnitudes respectively. Since the spectrum of a star of the second magnitude could be taken without clock-work, stars of the sixth and eighth magnitudes respectively could be photographed equally well with the arrangement described above."

The work already undertaken in this direction developed so rapidly that the Bache appropriation soon proved entirely inadequate to carry it further. Whereupon early in 1886, Mrs. Henry Draper, who from the first had taken a great interest in this work as a continuation of that so auspiciously begun by Dr. Draper himself, generously came forward and agreed to place at Prof. Pickering's disposal, not only the excellent eleven inch photographic telescope which Dr. Draper had so successfully used in his spectrum researches, but also a sufficient sum of money to enable the experiments already suggested to be fairly tried. In consequence, Prof. Pickering decided to continue the investigation along three more or less independent lines: First, he purposed to make a general survey of stellar spectra, each spectra being photographed with an exposure of not less than five minutes. These photographs exhibit in general the spectra of all stars brighter than the sixth magnitude, with sufficient distinctness for measurement. Second, he desired to undertake a determination of the spectra of the fainter stars, each photograph of this set receiving an exposure of an hour. All stars not fainter than the ninth magnitude, and included in a region ten degrees square, are represented upon a single plate. The work in both these directions has been done thus far with the Bache

photographic telescopes, 15,729 spectra having been already photographed and measured. Third, he decided to carry on a more careful study of the spectra of the brighter stars. For this work, the Draper eleven inch corrected refractor was specially used, a suitable observatory having been erected for it in Cambridge. Four prisms, each having a refracting angle of 15°, were constructed, of which three had a clear aperture of nearly eleven inches, the fourth being somewhat smaller. These four prisms with their mounting weighed more than a hundred pounds and occupied a cubic foot of space.

The original negatives have been enlarged by a novel process which gives most excellent results. A cylindrical lens is placed close to the enlarging lens with its axis parallel to the length of the spectrum. In the apparatus actually employed the length of the spectrum and with it the dispersion, is increased five times, while the breadth is increased nearly one hundred. This arrangement has the great advantage that it greatly reduces the difficulty arising from the feeble light of the star. Until recently, the spectra in the original negatives were made very narrow, since otherwise the intensity of the starlight would have been insufficient to produce the proper decomposition of the silver particles. The enlargement being made by daylight, the vast amount of energy then available is controlled by the original negative, the action of which may be compared to that of a telegraphic relay. The copies therefore represent many hundred times the original energy received from the stars.

It was with the apparatus above described and under these conditions, that the photographs were taken that I have the honor of exhibiting to the Society. Although the earliest satisfactory results were obtained in October, 1886, yet it is evident that the full meaning of these photographs can be discovered only after they have been carefully measured, and after these measurements have been reduced and thoroughly discussed. Some points of interest, however, appear on simple inspection of them. This photograph of α Cygni for example, which was taken November 26, 1886, shows the H line to be double,* its two components having a difference of wave-length of about one ten-millionth of a millimeter. This photograph of o Ceti shows the lines G and h as bright lines, as well as the four ultra violet lines which are the characteristic of spectra of the first type; to which Dr. Huggins gave the letters α, β, γ and δ. In this spectrum, however, the H and K lines are seen to be dark; showing that they do not belong to that series of lines. The spectrum of α Tauri shows a multitude of lines and bands, massed in the more refrangible region; thus accounting for the ruddy color of the star. The spectrum of Sirius shows, besides the well-known broad lines characteristic of this brilliant star, a large number of fainter ones. The spectrum of α Canis minoris, taken with four prisms, shows the solar dark lines G, h, H and K.

This entire research is entitled "The Henry Draper Memorial." The

* According to Young, the line H in the solar chromosphere, which is bright, is double also.

first annual report has just been issued by Prof. Pickering and contains an account of the investigations thus far made, together with the results obtained. It is illustrated with a plate (which I have the pleasure of placing before you) illustrating the rapid progress which has been made within the past few years in photographing stellar spectra. The first figure, which is a direct copy of the spectra obtained in 1885, was taken with the Voigtländer lens of two inches aperture having a 30° prism in front of it and shows the spectra of α Lyræ, α Aquilæ, α Bootis and β and γ Ursæ Majoris; the instrument having been directed successively to these stars and the plate exposed five minutes on each. The longest of these spectra is not over four millimeters in length. The second figure is the spectrum ζ Ursæ Majoris accompanied by that of an adjacent fifth magnitude star. It was taken with the larger Voigtländer lens, with an exposure of five minutes. It is about nine millimeters long and one wide, and illustrates the size of spectra used in preparing the catalogue of spectra of the brighter stars, one or two hundred of these being sometimes photographed on a single plate. The third figure represents the spectrum of α Lyræ, and was taken with the Draper eleven-inch telescope with two prisms, on November 5, 1886, with an exposure of fifty-nine minutes. This spectrum is a little more than fifty millimeters long and about two and a half millimeters wide. The fourth spectrum, taken on January 21, 1887, represents β Geminorum. The exposure was fifty minutes, four prisms being used with the eleven-inch Draper telescope. This spectrum is nearly eighty millimeters long. All these now described are original negatives printed by contact. The fifth figure in this plate represents a little more than half of the spectrum of β Geminorum (as given in figure four) enlarged by Prof. Pickering's special process above described. This spectrum is 220 millimeters long and seventy-five wide, and shows a mass of dense lines irregularly distributed. Below this is a narrow strip, fifteen millimeters wide, of the spectrum of the same star taken on January 12th. It is given for comparison and shows that practically all of the lines shown belong really to the star itself and are not produced in the photographic processes.

It is gratifying to know that Mrs. Draper has been so well satisfied with these splendid results that she has decided greatly to extend the original plan of the work and to have it conducted in the future on a scale suited to its importance. The attempt will be made to include all portions of the subject so that the final results shall form a complete discussion of the constitution and conditions of the stars as revealed by their spectra, so far as scientific methods at present permit. It is expected that a station will be established in the southern hemisphere, so as to permit the work to be so extended that a similar method of study may be applied to stars in all parts of the sky. The investigations already undertaken include (1) a catalogue of the spectra of all stars north of 24°, of the sixth magnitude or brighter, (2) a more extensive catalogue of spectra of stars brighter than the eighth magnitude, and (3) a detailed study of the spectra of the

bright stars. This last will include a classification of the spectra, a determination of the wave-lengths of the lines, a comparison with terrestrial spectra and an application of the results to the measurement of the approach and recession of the stars. A special photographic investigation will also be undertaken of the spectra of the banded stars and of the ends of the spectra of the bright stars. Beside the instruments already mentioned, there will be used the twenty-eight-inch and fifteen-inch reflectors constructed by Dr. Draper, which Mrs. Draper has decided to send to Cambridge for this purpose, and also the fifteen-inch refractor belonging to the Observatory.

From these statements it will appear that photographic apparatus has here been provided on a scale quite unequaled elsewhere. "But," says Prof. Pickering, "Mrs. Draper has not only provided the means for keeping these instruments actively employed, several of them during the whole of every clear night, but also of reducing the results by a considerable force of computors and of publishing them in a suitable form. A field of work of great extent and promise is open, and there seems to be an opportunity to erect to the name of Dr. Henry Draper a memorial such as heretofore no astronomer has received. One cannot but hope that such an example may be imitated in other departments of astronomy, and that hereafter other names may be commemorated not by a needless duplication of unsupported observatories but by the more lasting monuments of useful work accomplished."

Note added May 1, 1887.

The excellent phototype plate which accompanies and illustrates this paper, shows the enlarged positives of the spectra of α Tauri taken with two prisms and that of o Ceti taken with one. The negatives from which the phototype plate was prepared were kindly furnished me by Prof. Pickering especially for this purpose. My obligations are due to him, therefore, for this courtesy. I am also indebted to Mr. Gutekunst for the faithfulness of their reproduction.

It is a gratifying evidence of appreciation of Prof. Pickering's photographic work, that the National Academy of Sciences, at its meeting in Washington, in April, awarded to him the Henry Draper gold medal, for having in their opinion made the most important progress in Astronomical Physics during the two years which have elapsed since the preceding award.

Dr. Frazer made the following remarks:

A question suggests itself in relation to the very important results of Prof. Pickering, which Prof. Barker has so lucidly and interestingly described.

As the extremely minute point of light which is received on the first prism represents the radiation from every part of the star under examination, of course the line of light produced by the prism will represent at any infinitesimal fraction of time, the whole radiation of light from the

half of the star turned towards us during that time; and during an indefinitely short exposure might be said to represent the condition of the surface visible to us as it was during a certain minute time interval when the waves set out from that surface. [Neglecting for the moment the modification of this statement which the curvature of the star's surface would render necessary owing to the fact that the light which proceeded from the extreme outer edge would have a longer distance to travel than that in the centre by a little more than the radius of the star, and therefore its arrival at the instrument might be later than that from the central portion.]

But the broadening of this line into a surface by making a slight difference between the rate of the clock-work and the angular motion of the earth, would represent this same elongated surface of the star at different times. In other words the one axis would represent different parts of the star at the same instant of time, and the other axis would represent the same region (the hemisphere visible to us) at different periods of time.

If the movements of the atmosphere of the star observed were as rapid and extensive as those of our own sun, the consequence would be that we would have a succession of different conditions of the star's atmosphere placed in close juxtaposition, the whole series representing all the changes that had occurred in the star's photosphere during the interval of exposure. On this account it would seem that this method was not adapted to do more than give the resulting average of these changes on a sensitive plate of measurable breadth and would not permit the condition of the photosphere at any one instant of time to be studied.

It would be interesting to know what effect a similar procedure on the disc of the sun would show, by juxtaposing a large number of instantaneous photographs of the disc as different parts of the latter were successively brought over the slit of the spectroscope.

Notes on the Surface Geology of South-west Virginia. By John J. Stevenson.

(*Read before the American Philosophical Society, May 20, 1887.*)

New river, rising in North Carolina, flows across the Archæan area of Virginia, and enters the "Great Valley" of that State in Wythe county. It flows through Wythe and Pulaski counties, separates the latter from Montgomery, and flows through Giles county into West Virginia on its way to the Ohio river at Point Pleasant. It drains the counties named, with the addition of Bland. The most important forks of the Holston river flow through Smyth and Washington counties of Virginia into Tennessee; while the Clinch river rising in Tazewell county of Virginia flows through Russell and Scott counties and drains much of Wise. It is joined in Tennessee by Powell river, which drains Lee county and part of Wise.

The Clinch and Holston unite to form the Tennessee, through which their waters reach the Ohio at Paducah.

The effects of erosion in Bland county are seen in the removal of limestone and shales so as to throw the harder rocks into relief as mountains; to form narrow valleys in limestones near the present lines of faulting, and to scoop out a basin in Devonian and Upper Silurian shales. Within Giles county, New river flows on Knox (Calciferous) limestone, and the later rocks have been eroded from a considerable space on both sides of the stream. The conditions became approximately the same throughout this area after the removal of the Devonian and Upper Silurian, and good illustrations of certain types of erosion are afforded here as well as further southward along New river.

Remnants of two planes of erosion, one 225 (1810 feet above tide) feet and the other 115 (about 1670 feet above tide) feet above New river at Snidow's ferry, were seen in Giles county on the road from the county-seat to that ferry, which is opposite the mouth of Big Stony creek, where the altitude of the water surface is about 1555 feet above tide. The upper plane originally extended far into the recess between Pearis and Sugar run mountains;* and even now it can be recognized easily in the many hills, whose leveled tops have almost the same altitude. The second plane is more distinct, being better preserved than the other, and having a larger area. Still lower benches, river terraces, were seen, but they do not exist on the road followed by the writer, and no measurements of their height could be obtained.

The deposit on the higher planes is sand and clay, carrying vast numbers of transported polished fragments, most of which are barely three inches in diameter, though some were seen upwards of ten inches. For the most part, these pebbles are of local origin, or, at least, they came from the confines of the "Great Valley," for the sandstones predominate; but there are not wanting pebbles of glassy and milky quartz, seldom more than four inches in diameter, which must have come from the Blue Ridge, not less than seventy miles away by the nearest water-line. And these are found on the highest bench at nearly three miles from the river's present channel way.

A fine plane of erosion is well preserved on both sides of New river south from Little Walker mountain in Pulaski and Montgomery counties. Its summit is shown on the west side of the river near Belspring station, with an altitude of not far from 1775 feet above tide, the station being 1766 feet A. T., while a higher plane is reached along the New River R. R. on this side of the river at the summit cut, two and a half miles from New River station, and about 1925 feet above tide, the track in the cut being

* For explanation of the relations of the mountains and of most of the localities referred to in this paper, the reader is referred to memoirs on Southwestern Virginia, published by the writer in Proc. Amer. Phil. Soc., as follows: Vol. XIX, pp. 88, 219, 498; XXII, p. 114, and XXIV, p. 61. The faults are described summarily in a paper in the Amer. Journ. of Science for April, 1887.

1914 feet. This bench extends eastward from New river for more than eight miles between Little Walker and Price mountains, and it is probably the same with the fine terrace shown above the railroad bridge over New river. It is distinct on the west side at four miles from the river on the railroad; and it appears to be the same with the plain seen nearly six miles further west on the road leading across Pulaski county from Dublin to Pearisburg; but the barometric readings on that road are not wholly satisfactory.

The deposit on these benches is of clay and sand, containing pebbles of varying size, most of them, as before, of local origin, but not a few of them have come from the Blue Ridge. The upper bench is deeply trenched here and there by narrow valleys in which rock exposures occur; elsewhere such exposures are rare, as the detrital cover is from five to thirty feet thick. River terraces, apparently unbroken and almost as perfect as those shown in theoretical diagrams were seen in the "Horseshoe bend" bottom, but they could not be reached for measurement.

Erosion planes are equally well marked along New river within Wythe county for some distance above and below the Wythe lead and zinc mines. The lead company has sunk a shaft at about half a mile south from New river, beginning at the topmost part of the bench, which, according to the barometer, is 310 feet above the river at Thorn's ferry opposite the company's offices, or 2260 feet above tide. The surface is covered with loose boulders, mostly three inches or less, though some are fully eight inches. The deposit, as found in the shaft, is nearly fifty feet thick, and the bench is of great extent on this southerly side of the river. Crossing to the other side and taking the road over Lick mountain to Wytheville, one soon comes to a bench, 120 feet by barometer above the river or 2070 feet above tide. This was not recognized at the lead mines on the southerly side of the river, but on this side it is distinct almost from Jackson's ferry to the Wytheville road, on which it is reached at three miles from New river. The higher bench is reached by the Wytheville road at six miles from the river, and, according to the barometer, is 320 feet above low water at Thorn's ferry or 2270 feet above tide. It carries a thick coat of debris loaded with pebbles.

The tributary streams of New river are terraced. A fine bench was seen on Wolf creek in Giles county at a mile or so from the river. It is sixty-five feet above the stream and carries a thick deposit, which is rich in rolled stones. The upper terrace of Reed creek below Wytheville was not measured, but it is fully 150 feet above the stream. It shows huge boulders of Potsdam sandstone resting on the Knox limestone, though a broad and deep ravine separates their resting place from Lick mountain, whence they came. An erosion plane, similar to that seen in Pulaski county, was observed north from Wytheville within the New river area. Its superficial deposit of sand, often carrying many pebbles, is so thick as to conceal the bedded rocks for long distances.

Great planes of erosion are shown in all parts of the "Valley" from the Tennessee line to the eastern side of Montgomery county; no doubt they are continuous thence into Pennsylvania, where such planes are sufficiently distinct. At all localities they illustrate effects of erosion during a long period in which the channel-ways of the main streams are not deepening materially.

By some means the erosive or channel-deepening power of the New river has been greatly increased since the erosion of the upper planes was completed; for the river has excavated a gorge 255 to 300 feet deep with the hills abrupt on one or both sides for considerable distances; while erosion extends at best to but a little way from the river. The tributary streams flow for the most part in comparatively narrow valleys, even where the conditions appear to be such as to favor extended erosion. Meanwhile the destruction of the elevated planes has gone on irregularly; the upper bench south from Walker mountain has suffered little in Montgomery county except near the river. But that in Giles county has been eaten away and another, widely extended, has been formed at a lower horizon; and there appears to be nothing south from Walker mountain to compare in extent with the lower plain north from that mountain.

While the erosion of the "Great Valley" and of the region drained by New river appears easily referable to a simple plan, the conditions in the limestone area of Tazewell, Russell and Scott counties, drained by Clinch river, are not so clear. Benches exist, but they are not so obvious as are those in the valley, they do not always carry a deposit loaded with pebbles and they seem rarely to have great extent. One gravel deposit was found on the line between Russell and Scott within a mile of Clinch river and at 640 feet above that river at Osborn's ford, making its height above tide not far from 1920 feet. The pebbles are rarely larger than a hen's egg, and are mostly quartz; comparatively few could have been derived from the region now drained by the Clinch, and most of them must have come from the Blue Ridge or further at the south.

The Clinch and North Holston are as handsomely terraced as the New river and its tributaries. The "bottom" of Clinch river appears to maintain a uniform height of about fifteen feet above low water; a fine terrace is shown near Osborn's ford at ninety-five feet above the river or 1375 feet above tide, and it is present on both sides of the river at a little way above the ford. A higher bench is shown on the southerly side, but its height could not be ascertained. Near Nash's ford in Russell county, three terraces are crossed as one descends to Clinch from the south. These are about 155, 40 and 15 feet above low water at the ford. The highest reaches far back from the river and its height above tide is not far from 1700 feet. A fine terrace was seen on the north fork of Holston below the mouth of Laurel creek in Smyth county, where the top of the deposit is between eighty-five and ninety feet above the river or at not far from 1625 feet above tide. The deposit on these river terraces consists of sand and clay carrying abundance of boulder, all apparently of local origin.

In some portions of South-west Virginia, notably in the region embracing much of North-west Tazewell county, Virginia, and of Mercer and Summers counties of West Virginia, which is known as "Flat Top," there are high benches or fragmentary plains which are of considerable extent, but do not appear to carry many water-worn stones in their thin cover. They are very like the higher benches observed by the writer* in South-west Pennsylvania, and very possibly they are due to the same causes.

But what these causes were is still an open question. The most natural explanation is that which regards them as erosion planes, such as were termed "base levels of erosion" by Major Powell. But in discussing these benches as they occur in Pennsylvania and adjacent States, the writer showed that as they line valleys and form irregular rings about isolated hills, they are merely incidental modifications of a topography due to prior and long continued erosion; and that they are too well preserved to be regarded as fragments of great erosion planes. More than this. The deposit on these benches is marked by the absence of water-worn and rounded fragments; the absence of such fragments cannot be accounted for by the supposition that they have been broken up by exposure, for the greater part of the deposit has been protected from atmospheric agencies until exposed by the plough or in excavations for roads. The Coal Measures of Western Pennsylvania contain sandstones, whose fragments should resist disintegration equally with the Medina and Potsdam pebbles of South-west Virginia; while in Bedford county of the former State, where high benches are as conspicuous as in the Coal Measures counties further west, the Chemung conglomerates and the Medina sandstones are present and the stream beds are loaded with their fragments; yet no rounded pebbles were seen on the benches.

The absence of these boulders militates against any application of the base-level process, as generally understood, and equally against the supposition suggested by the writer, that the benches were produced by shore erosion between tides. The problem of their origin is not simplified by denying their existence, for, unfortunately, the benches are "here to stay." A ride along the National road in Pennsylvania, from Uniontown in Fayette county to Washington in Washington county, enables one to secure a key to the whole succession.

Returning to Virginia. That the great erosion has occurred since the faulting took place is sufficiently shown by the contrast between the upthrow and downthrow sides of the faults; for on one side is seen the highest portion of the Lower Carboniferous, while on the other are the lowest beds of the Knox limestones. It may be that the main streams antedated the faults and possibly the folds. The course of New river, which rises far beyond the axis of the Blue Ridge crosses at least six great faults as well as all the folds, great and small, from the Blue Ridge to the Ohio river, suggests that it may be following in a general way the original direction.

*Proc. Amer. Phil. Soc., Vol. XVIII, Aug. 15th, 1879.

But there have been great changes in the water-ways. The fragmentary deposit on the line between Russell and Scott counties, carrying quartz pebbles at 640 feet above Clinch river, tells the story of one great change, for nothing along the upper Clinch could furnish the material for this deposit, of which so little remains. The deep erosion near the North fork of Holston river, from Saltville in Smyth county eastward for sixteen miles, cannot be referred to any present drainage system; its bottom is more than 600 feet below the present bed of the river and the excavation has been filled with a deposit of gypsum and rock salt. This was digged out after the faulting, for the excavation crosses and re-crosses the Saltville fault.*

It is sufficiently clear that the courses of many of the present streams are due in no small degree to the geological structure. The fans formed by the Clinch and Holston with their tributaries show a co-incidence with the general course of the rocks and faults which cannot be merely fortuitous. Tributaries to New river in Bland and Giles counties flow irregularly with the strike of the beds; between outcrops of sandstone they follow the more readily yielding rocks, so that they are often brought near to the fault lines; and many streams belonging to the other systems do the same. But in the broad limestone areas, some other cause has determined the direction, for not a few streams exist there whose courses appear to bear no relation to the geological structure. No especial weakness now exists in the immediate vicinity of the faults, for the streams flow with utter indifference to them. New river crosses all of the faults. Big Walker creek and the North fork of Holston flow back and forth over the Saltville fault, and the latter at times wanders to a distance of two or three miles, apparently without reference to the character of the rocks. Clinch river coquettes in the same way with the Clinch faults and eventually deserts them to cross the limestone area in Scott county and to cut the Copper creek fault at ten miles toward the south-east. The North fork of Clinch crosses two faults and many of the smaller streams flow directly across one or more.

It is altogether probable that the present lines of the faults are very far, in some cases at least, from the original lines. The lateral thrust in more than one case must have been enough to push the upthrown rocks to a considerable distance over upon the downthrown series; so that the areas of weak or crushed or much distorted rocks lay north or north-west from the lines as now observed. The crushed portions have been removed by erosion and the streams have changed their channel-ways as the erosion advanced. It is difficult, therefore, to determine much respecting the former drainage ways.

The thickness of rock removed by erosion in this region, though not equal to that removed from Western Colorado and adjacent parts of Utah, is still sufficient to challenge respect. There is no room for doubting that the Coal Measures reached at one time beyond the "Valley" to the Blue

*See Proc. Amer. Phil. Soc., Vol. XXII, p. 154 *et seq.*

Ridge, for those rocks are just missed on the northerly side of the Draper Mountain fault, at twelve miles from the Blue Ridge. Even now the Coal Measures must be caught on some of the Washington county hills beyond the Saltville fault. The Lower Potsdam is brought up under the Lick Mountain anticlinal at not more than four miles from the line of the Lower Carboniferous in the Draper Mountain area. The whole of the Palæozoic column, then, or not less than 22,000 feet, has been removed from the westerly side of the Blue Ridge in South-western Virginia; while in the "Valley" and on the upthrow side of the faults the thickness of removed rocks is from say 18,000 feet in Lick mountain to 12,000 feet or more along the faults. Additional proofs of this enormous erosion are found in the occurrence of Lower Silurian valleys separated by ridges carrying small areas of the Coal Measures.

This enormous erosion occurs only on the upthrow side of the faults; so that on the downthrow side one may find even the Coal Measures, while the lower beds of the Calciferous may be on the other. So, 15,000 feet or more may have been removed from one side, while on the other, the whole loss may not exceed 3000 or 4000 feet. This great contrast between the two sides seems to suggest that the lateral thrust was enough in every case to *push the upthrown beds far over on the downthrown*, so that there could be no erosion of the latter until after removal of the former.

Of course, there are perplexing problems here; they usually abound. One is suggested by the successive increase in height of the erosion planes as one ascends New river. Thus the highest south from East River mountain is at 1810 feet above tide; that south from Big Walker mountain is at about 1925 feet; while that south from Draper and Lick mountains is at about 2270 feet. These benches were all made during a long period when the river in each area had practically ceased to deepen its channel-way. It may be that the Medina sandstone of Draper mountain, the Chemung conglomerate and Medina sandstone of the Walker mountains and the Medina sandstone of the East River mountains may have proved sufficiently hard to resist erosion for a long time. However that may be, corrasion advanced regularly after it began, for the first bench below is reached at 140 feet south from East River mountain, at 150 feet south from the Walker mountains, and at nearly 200 feet in the space between Lick mountain and the Blue Ridge.*

A long halt in corrasion occurred during the formation of the second bench; but thenceforward no important obstacle seems to have been encountered and the interruptions were only long enough to admit of forming narrow river terraces, which usually are found on but one side of the river.

University of the City of New York.

* For the elevations along New river, I am indebted to Mr. W. W. Coe, Chief Engineer of Norfolk and Western R. R.; and for those on the Clinch and Holston rivers to Mr. Oramel Barrett, Jr., of Abingdon, Virginia.

The Signal Service Bureau. Its Methods and Results. By William Blasius.

(Read before the American Philosophical Society, May 6, 1887.)

In 1872 the Leipzig Conference propounded this question, with others, to the principal meteorologists of the world: "Are you of the opinion that the present state of our knowledge of the weather justifies giving definite prophecies or predictions instead of the telegraphic communication of facts, or shall we limit ourselves to intimations upon the state of the atmosphere in the surrounding countries, from which the receivers of the communications may deduce their own rules?"

The replies were almost uniformly in the negative, and among them that of the very distinguished meteorologist, Prof. Buys-Ballot, of Utrecht, who said: "No prophecies, if we do not want to bring this matter into discredit. It is impossible for the director to say on which part of the coast the wind will blow first, and be the strongest, if he does not await the beginning of the storm at a place at some distance, and then it is too late. The state of the weather may be given. Every one may have the fixed rules by which, from this state, he may deduce his own results." And then, in a humorous way, he adds: "He who shall predict the weather, if he does it conscientiously and with inclination, will have no quiet life any more, and runs great risk of becoming crazy from nervousness."

The United States Signal Service Bureau has from the beginning—owing to the nature of its organization perhaps—taken a different course; it has devoted its chief efforts to *prediction* and *signaling*, while the study of nature and its laws has received but scant attention. And what is the result? Can it now give the "fixed rules," of which Buys-Ballot speaks, by which every one may be enabled to form some judgment of the weather? What additions to meteorological science has it ever made? Is there even one valuable result in all its voluminous literature that cannot be found in the prior works of others? If so, where and what is it? Nay, more. It has published during the last twenty years a vast conglomeration of facts and observations, at great expense of labor, intelligence and money, but from all this great material have any meteorologists the world over been able to make generalizations that have been accepted as sound and valuable?

I think, upon reflection, we must all see that the answer cannot be affirmative, and that when the results of the Signal Service Bureau's work are summed up, it is found to be utterly disproportionate to the means at its disposal, even in the matter of prediction. Its methods must therefore be at fault. Let us examine.

At the close of our civil war, upon the suggestion of the late Prof. Henry, the Telegraph Corps, whose services in the field as an active part of the army were no longer needed, was reorganized as the Signal Service Bureau, and its officers and soldiers became at one stroke, full-fledged meteorologists, but remained under strict army discipline, and worked under

rigid rules. The duties assigned to them individually were, however, and still are of a very simple nature. The "observers" at the various stations, at certain hours of the day, record in tabular columns the readings of their meteorological instruments, and telegraph these to Washington; and since my work on "Storms"* was published in 1875, in which I called especial attention to the Bureau's neglect of cloud forms, some simple observations upon the clouds are added to the telegraphic reports. Upon receipt of these reports at Washington, they are written down upon blank maps, on which the respective stations are marked. The points of lowest equal barometric pressure are then united by a line called the Isobar which usually form an ellipse. In the same way the stations of five or ten points of higher pressure are joined by a line. The field enclosed by these somewhat concentric Isobars is the "area of low pressure," or the "cyclonic storm" so called. From the results of the next reading the next position of the area of low pressure is ascertained in the same way, and by comparing the distance traveled with the time occupied, the probable position for some hours ahead is calculated, and predictions are issued. The labor is thus of a routine character.

"Areas of high barometer" are likewise noted, but these are thought to bring fair weather. The barometer therefore is still the chief reliance in the prediction of storms, and those storms which are distinguished as "areas of low pressure" are practically all that the Signal Service is able to predict.

Now, in the report of the Chief Signal Officer for 1884, there are noted as having occurred during the year 152 of these areas of low pressure, 172 tornadoes, 947 hailstorms, and 1745 thunder-storms, so that if every one of the 152 "cyclonic storms"—the "areas of low pressure"—are correctly predicted, we have some 2864 storms, of which the Bureau knew nothing until after they had occurred. Relying on the barometer and on machine methods, it could not be otherwise.

Lieut. J. P. Finley, Chief of the Tornado Division of the Bureau, in "Signal Service Notes, No. XII," says: "Probably if a barometer were placed in the immediate track of a tornado cloud, it would not with any certainty indicate the presence of the storm until the crushing winds had fallen on the instrument." Indeed, although the Bureau appears to proceed on the old rule that has obtained predominance since the days of Otto von Guericke, that a falling barometer denotes an approaching storm, it has long been well known that the most destructive storms often arrive with a rising barometer, and this for reasons that I explained as long ago as 1852. One of these storms took place at Colon, or Aspinwall, Panama, December 2, 1885. The New York *Herald* of December 18 says: "This storm was not preceded by any distinct precursory signs. The barometer on the Isthmus apparently remained stationary or slowly rose during the progress of the tempest. Much property, many vessels and lives were lost."

*Storms: Their Nature, Classification and Laws. Porter & Coates, Philadelphia, 1875.

One of the most destructive storms this country has ever witnessed, occurred on the coasts of Nova Scotia and Newfoundland, August 23, 24 and 25, 1873, by which about 500 lives were lost and 1032 vessels destroyed, including 435 small fishing schooners. The Signal Service Bureau was entirely taken aback by this storm, because an "area of high pressure" or an "anti-cyclone" had been moving from Manitoba to the coast, and therefore, fair weather was to be expected. But in the weather maps for several days previous could be traced the gradual advance of a wave of cold air from the North—the "area of high pressure"—which banking up the warmer air in its front as shown by the gradually rising gradient, finally culminated in a terrific south-east storm with its centre of destruction on the coast. We thus have a storm of the most violent character traced on the maps of the Signal Service Bureau for several days as a fair weather indicator.

The Chief Signal Officer reports 80 "areas of high barometer" during 1884. Those occurring in the cold season mean fair weather, as they displace the warm current which has previously discharged its moisture. In the summer, however, this cool air from the North, which being heavy can be identified as an "area of high pressure," causes—in its displacement of the then prevailing warm and moist air—the south-east storm, with its tornadoes, hail-storms, cloud-bursts and thunder-storms, none of which the Signal Service Bureau predicts, and which cause vastly more destruction than the north-east storms—the "areas of low pressure"—both from their greater violence, and because they mostly occur at a season of the year when the work of the agriculturist is going on and his crops—on which the nation depends for its prosperity—are subject to injury.

It is true that quite lately the Bureau has turned its attention to this branch of the subject, after so many years of practical neglect, and that claims of considerable magnitude have been advanced as to what has been accomplished and what will be accomplished, both in the way of prediction and scientific discovery. Let us therefore examine into this a little.

The most eminent of American meteorologists—Redfield, Espy and others—agree in thinking the tornado the most instructive of all storms. It is in some respects the type of our American storms, since here the opposition of air-currents of different temperature and density, which is the general cause of storms, is most strikingly manifested and within the narrowest limits.

Mr. Wm. A. Eddy, an attaché of the Bureau, in *The Popular Science Monthly* for January, 1886, says: "During the first part of 1884, the United States Signal Service began to pay special attention to the question of tornado prediction. The development of the science was rapid under the active supervision of Lieutenant John P. Finley, having charge of that department of the service. It was found that the public interest in the question was widespread, and that with the aid of voluntary reporters of tornado phenomena, the possibility of saving life and property had begun to crystallize into a practical scheme." He further says: "During the

summer of 1886, it is hoped that, by means of signals, hundreds of lives and much valuable property will be saved."

The summer of 1886 has passed; can it be said that this hope is realized? Has the Signal Service saved a single life or any property by its tornado predictions?

Mr. Eddy tells us that the "invariable location south-east of the storm-centre is one of the main peculiarities of tornado development upon which the predictions depend." And yet to this same peculiarity, with its explanation, I called attention as early as 1852, and again in 1875, in the publication of my work on storms already referred to, and I urged it on the Signal Service Bureau during a personal visit to Washington at that time.

Mr. Eddy also says: "When the conditions are unfavorable for the development of tornadoes, there are no unusual contrasts of temperature, the areas of warm and cold air neither great nor well defined northward and southward, the winds are variable and not very strong, and the distribution of pressure is about normal." All this can be found in my work on "Storms," published in 1875—why is it put forward as a new discovery in 1886?

Indeed, it was only after the publication of that work that the Signal Service Bureau began to note the difference of temperature in air-currents—to which I had called attention—and made various and important changes in its method of prediction. But when Lieutenant Finley puts forth as a discovery of his own, the fact that tornadoes are caused by "two opposing air-currents of different temperatures and moisture," it seems a little singular, in view of my communication of the same fact to the Academy of Science in Boston, in 1851, its publication in 1852, and again, in 1875.

As to the prediction of tornadoes by the Signal Service, it can never be done with any certainty, except in so general a way as to be valueless. If any one has mastered the principles of atmospheric disturbance—and they are not so difficult—he will be able to judge for himself as to the probability of tornadoes being imminent in his locality ten times as well as the Signal Service can ever tell him. Just where the tornado will strike, and its path is a narrow one, no man can tell until within a few minutes of its passage.

Mr. Eddy says: "That during 1884, 3228 predictions *un*favorable to tornadoes were made, and of these 3201 were verified." But what a simple matter it is with the most ordinary knowledge and circumspection to say that tornadoes will *not* take place, when the dark clouds of the south-east storm give ample notice when there is a possibility of their happening? If we have a south-east storm we may or may not have tornadoes; but if we have *not* a south-east storm, then we have no tornadoes.

As to the prediction of a tornado itself, Mr. Eddy cites that which passed over Camden and Philadelphia, August 3, 1885, as "one of the best illustrations of the advance made in definiteness in predictions;" and he further says: "The chart used by Lieutenant Finley shows that tornadoes were predicted and their location marked upon the map for the State

of Delaware, South-eastern Pennsylvania and for New Jersey. The tornadoes actually occurred in these States, about eight hours from the time of prediction."

Now if we ask how valuable to the owners of the houses damaged by that tornado in Philadelphia was the Signal Service's prediction eight hours before, that tornadoes would occur somewhere in "Delaware, South-eastern Pennsylvania or New Jersey," we cannot fail to see, I think, the entire impracticability of the whole scheme.

The Signal Service is perhaps obliged by circumstances to devote most attention to those things which will show most apparent results to the general public and to Congressmen who vote for the annual appropriation. It is hampered too by its routine methods and its army rigidity of discipline. It cannot however but be a cause of disappointment that whether owing to these causes or others, it has added so little of scientific value to the knowledge of meteorology during the twenty years of its existence. It has been following the old methods in reference to which Sir William Herschel says: "In endeavoring to interpret the weather, we are in the position of a man who hears, at intervals, a few fragments of a long history, related in a prosy, unmethodical manner; a host of circumstances omitted or forgotten, and the want of connection between the parts prevents the hearer from obtaining possession of the entire story." And the great Biot, after enumerating the efforts to advance this science, says: "What has come of it? Nothing, and nothing will ever come of it. No single branch of science has ever been fruitfully explored in this way."

No, the methods followed have been wrong. Would astronomy be in its present position if the great astronomers had been dependent on the data furnished by observations made according to arbitrary rules, and for a minimum of time at one or two hours of the night, and for the most part, too, by observers of meagre training and intelligence? And how much would the great naturalists have learned, had they been content to send out into the fields three times a day for five minutes, and sit in their closets to generalize upon the data thus obtained?

Thirty-five years ago, I urged that only by *continuous* observations could we hope for anything beyond mere empirical knowledge; that we must gather up the "host of circumstances" now "omitted or forgotten," and supply "the connection between the parts." I am not unmindful of the practical difficulties that are in the way of a method of observation that alone can give a continuous knowledge of a storm as it passes; but it seems to me that this may be obtained with the means now available, if the meteorological organization would devote more attention to the discovery of general laws than to the more sensational part of their duties—the weather predictions, which the newspapers now make a matter of business enterprise. If we know the laws, there will be little trouble about the prediction. Each of us can do this for himself sufficiently well for all practical purposes.

Stated Meeting, December 17, 1886.

Present, 39 members.

President, Mr. FRALEY, in the Chair.

Correspondence was submitted as follows:

Letters of envoy from the Musée Teyler, Leyden, and Meteorological Office, London.

Letters of acknowledgment from Serge Nikitin, St. Petersburg (123); Dr. Paul Albrecht, Hamburg (121, 122, 123); R. Accademia dei Lincei, Rome (122); Mr. William John Potts, Camden (123).

The College of Physicians requested, by letter, the oil portraits of Dr. Franklin Bache, Dr. Elisha Kent Kane and Dr. Joseph Priestley, for use at its approaching Centennial.

On motion, the paintings were ordered to be loaned, the Curators taking proper guarantees for their safe keeping and return.

Accessions to the Library were announced from the following:

Geological Survey of India, Calcutta; Naturforscher-Verein, Riga; Fondation de P. Teyler, Harlem; Astronomische Nachrichten, Kiel; Zoologischer Anzeiger, Leipzig; Messrs. R. Friedlander & Sohn, Berlin; Académie Royale de Belgique, Bruxelles; Biblioteca Nazionale Centrale V. E. di Firenze; Société d'Emulation, d'Abbeville; Société Historique Littéraire; Artistique et Scientifique du Cher, Bourges; Société des Sciences Naturelles et Archeologiques de la Creuse, Guéret; Institut de France, Sociétés de Geographie, Geologique, Zoologique, Musée Guimet, Ministéres de la Marine et de l'Instruction Publique, Paris; Meteorological Council, Nature, London; American Journal of Science, New Haven; Museum of Comparative Zoölogy, Prof. Benjamin A. Gould, Cambridge; Messrs. Walter Baker & Co., Dorchester; American Chemical Society, New York; Mr. George A. Bacon, Publisher, Syracuse; College of Pharmacy, Publishers of the American

Naturalist, Messrs. Chas. A. Lagen, Henry Phillips, Jr., Philadelphia; Johns Hopkins University, Baltimore; Department of State, Public Opinion Co., Washington; Academy of Sciences, St. Louis; Geological and Natural History Survey of Minnesota, St. Paul; University of California, Sacramento.

On motion the following were ordered on the Society's exchange list to receive Proceedings from No. 119:

La Ministère de la Marine Imperiale, Administration générale de la Hydrographie, St. Petersburg; Société Historique, Littéraire, Artistique et Scientifique du Cher, Bourges, France; Société des Sciences Naturelles et Archéologiques de la Creuse, Gueret, France; R. Societa Italiana d' Iginie, Milan.

A photograph was received for the Society's album from Prof. Serge Nikitin, St. Petersburg, Russia.

The death of Hon. Isaac Lea, LL.D., was announced by the President in some appropriate remarks, as having taken place at Philadelphia, on December 8th, in the ninety-fifth year of his age, and on motion, the President was authorized to appoint a suitable person to prepare the usual obituary notice.

The Committee on Finance made its report and, on motion, the appropriations for the ensuing year were passed to the same amounts and for the same purposes as those of the last year.

On motion of Dr. Allen, the Society extended an invitation to the American Society of Naturalists to visit its hall during the forthcoming meeting.

On motion of Mr. Ames, the Society ordered that new electrotype plates should be prepared for a table for the interconversion of English and metric units by Dr. Frazer, he stating that the old ones were worn out.

This being the stated meeting for balloting for candidates, an election was held and the following were declared to have been chosen members of this Society:

2105. Prof. Morton W. Easton, Philadelphia.

2106. Prof. William F. Norris, M.D., Philadelphia.

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2107. Prof. James MacAlister, Philadelphia.
2108. Charles S. Dolley, M.D., Philadelphia.
2109. Prof. John A. Ryder, Philadelphia.
2110. Prof. Hermann V. Hilprecht, Ph.D., Philadelphia.
2111. George W. Childs, Philadelphia.
2112. Prof. W. B. Scott, Princeton, N. J.
2113. Sir Henry Sumner Maine, F. R. S., London.
2114. Sir Monier Monier-Williams, F. R. S., Oxford.
2115. Prof. Dr. Hugo Von Meltzel, Koloszvar.
2116. Prof. Dr. Paul Hunfalvy, Buda-Pesth.
2117. Prof. Dr. G. Weil, Berlin.
2118. Prof. Dr. Henri Kiepert, Berlin.
2119. Prof. Dr. Adolph Bastian, Berlin.
2120. Prof. Dr. Friederich Mueller, Vienna.
2121. Prof. Dr. Matthæus Much, Vienna.
2122. Prof. Dr. A. Reville, Paris.
2123. Prof. Dr. Paul Topinard, Paris.
2124. Prof. Dr. Remi Simeon, Paris.
2125. Prof. Dr. Conrad Lemanns, Leyden.
2126. Prof. Dr. George Curtius, Leipsic.
2127. Julius Platzmann, Leipsic.
2128. Prof. Lucien Adam, Rennes.
2129. Prof. Guido Cora, Milan.
2130. Bishop Crescencio Carrillo, Merida, Yucatan.
2131. Prof. Juan de Dios de la Rada y Delgada, Madrid.
2132. Vicomte Hyacinthe de Charency, St. Maurice-les-Charency, France.
2133. G. A. Hirn, C.E., Colmar, Alsace.

And the Society was adjourned by the President.

Stated Meeting, January 7, 1887.

Present, 24 members.

President, Mr. FRALEY, in the Chair.

Dr. Marshall, a lately-elected member, was presented to the Chair, and took his seat.

Correspondence was read as follows:

Acknowledgments were received from: Société Historic Littéraire, Artistique et Scientifique du Cher, Bourges (96–123); Royal Institution, Society of Antiquaries, Royal Horticultural Society, South Kensington Museum, Mr. R. W. Rawson, London; University Library, Cambridge; Prof. I. Geikie, Edinburgh; Free Public Library, New Bedford (123).

Acceptance of Membership.—Prof. Charles S. Dolley, Prof. Morton W. Easton, Dr. Hermann V. Hilprecht, Prof. James MacAlister, Dr. Wm. F. Norris, Prof. John A. Ryder, Philadelphia; Prof. Wm. B. Scott, Princeton, N. J.

Photographs were received for the Society's Album from Messrs. Wm. Blades and H. Carvill Lewis.

Accessions to the Library were reported from the Asiatic Society of Japan, Yokohama; Royal Asiatic Society (North China Branch), Shanghai; Messrs. R. Friedlander & Sohn, Berlin; Gartenbauverein, Darmstadt; Dr. A. Weisbach, Freiberg; Astronomische Nachrichten, Kiel; Der Naturforscher, Tübingen; Société Batave de Philosophie Experimentale de Rotterdam; Sociétés Malacologique, Entomologique de Belgique, Académie de Belgique, Bruxelles; Biblioteca Nazionale Centrale di Firenze; R. Società Italiana d'Igiene, Milan; R. Accademia dei Lincei, Rome; Société de Geographie, Ecole Libre des Sciences Politiques, Revue Internationale de l'Enseignement, Paris; Sociedade de Geographia de Lisboa, R. Academia de la Historia, Madrid; Revista Euskara, Pamplona, Spain; Royal Society, Royal Astronomical and Geographical Societies, Greenwich Observatory, Royal Horticultural Society, Liverpool; Natural History Society, Montreal; Mr. George L. Vose, Boston; Yale College,

American Journal of Science, New Haven; Meteorological Observatory, American Chemical Society, New York; Franklin Institute, American Journal of Medical Sciences, Publishers of the American Naturalist and the Naturalist's Leisure Hour; Prof. Angelo Heilprin, Henry Phillips, Jr., Mrs. Zelia Nuttall, Baltimore, Md.; United States Naval Institute, Annapolis; Johns Hopkins University, Baltimore, Md.; United States Commission of Fish and Fisheries, Navy Department, Public Opinion Co., Washington; Washburn College, Topeka; Imperial Observatorio, Rio de Janeiro.

An obituary notice of the late Judge James R. Ludlow, prepared (by request) by Hon. Richard Vaux, was read by the Secretary.

The President announced the death of Pliny Earle Chase, LL.D., Vice-President of the Society, December 17, 1886, æt. 65, and, on motion, was authorized to appoint a suitable person to prepare the usual obituary notice, pursuant to which the selection of Hon. Philip C. Garrett was made.

The President announced the death of Mrs. Emma Seiler December 21, 1886, æt. 65.

The President reported that, pursuant to the resolution of the last meeting, he had appointed Prof. Joseph Leidy to prepare the obituary notice of the late Isaac Lea, LL.D., and that said appointment had been accepted.

The stated business of the meeting was then taken up, and the report of the tellers of the annual election being received, the following officers and councilors were declared duly chosen for the year 1887:

President.

Frederick Fraley.

Vice-Presidents.

E. Otis Kendall, W. S. W. Ruschenberger, J. P. Lesley.

Secretaries.

G. F. Barker, D. G. Brinton, Henry Phillips, Jr., George H. Horn.

Curators.

Charles G. Ames, John R. Baker, Philip H. Law.

Councilors for three years.

Daniel R. Goodwin, Henry Winsor, William A. Ingham, Thomas H. Dudley.

Councilor for two years in place of Oswald Seidensticker, resigned,

Richard Vaux.

Treasurer.

J. Sergeant Price.

This being the evening for the nomination of a member to serve as Librarian for the ensuing year, Dr. D. G. Brinton renominated Mr. Henry Phillips, Jr., Dr. Persifor Frazer nominated Admiral E. Y. McCauley, and the nominations were closed.

Dr. D. G. Brinton read "Some Critical Remarks on the Writings of Diego de Landa."

Pending nomination No. 1151 and new nomination No. 1152 were read.

A report was presented by the Committee on Library, accompanied by the following resolution, which was adopted by the Society:

"*Resolved*, That the Society request that the Library be kept open during the year 1887 from 10 A.M. to 3 P. M. from January 1st to May 31st and from October 1st to December 31st."

A communication was read from Mr. E. Muybridge, requesting a subscription to his proposed work on "Animal Locomotion."

On motion the Library Committee was directed to report at the next stated meeting of the Society on the expediency of subscribing to it.

And the Society was adjourned by the President.

Stated Meeting, January 21, 1887.

Present, 87 members.

Mr. RICHARD VAUX in the Chair.

Prof. James A. MacAlister, a newly-elected member, was presented to the Chair and took his seat.

Correspondence was submitted as follows:

A letter of envoy from the Real Academia del la Historia, of Madrid, Spain, accompanying certain numbers of its publications, for which a request had been made.

A letter from Prof. Horsford, in relation to Heckewelder's MS. vocabulary of the Lenni-Lennape, etc., was referred to the Secretaries with power to act.

Letters of acknowledgment from the Statistical Society, London (121, 123); Portland Society of Natural History; New Hampshire Historical Society, Concord; State Library of Massachusetts, Boston; Museum of Comparative Zoölogy, Mr. Robert N. Toppan, Cambridge; Essex Institute, Salem; American Antiquarian Society, Worcester; Rhode Island Historical Society, Providence; Connecticut Historical Society, Hartford; Prof. James Hall, Albany; Prof. C. H. F. Peters, Clinton; Dr. J. J. Stevenson, University of the City of New York, Astor Library, New York; Oneida Historical Society, Utica; U. S. Military Academy, West Point; New Jersey Historical Society, Newark; Dr. George H. Cook, New Brunswick; Rev. James A. Murray, Carlisle; Prof. M. H. Boyé, Coopersburg; Prof. J. W. Moore, Easton; Numismatic and Antiquarian Society, Drs. S. W. Gross, C. A. Oliver, Messrs. T. U. Walter, Thomas M. Cleeman, Henry Phillips, Jr., Philadelphia; Maryland Institute, Baltimore; Surgeon-General's Office, Washington, D. C.; Leander McCormick Observatory, Prof. J. W. Mallet, University of Virginia; Elliott Society, Charleston; Georgia Historical Society, Savannah; Cincinnati Observatory; Chicago Historical Society; Rantoul Literary Society; State Historical Society of Wis-

consin; University of California; Prof. John L. LeConte, Berkeley, Cal. (124); Prof. James MacAlister, Philadelphia, (121, 122, 123 and 124, etc.).

Accessions to the Library were received from the Administration Générale de la Hydrographie, St. Petersburg; Bataviaasche Genootschap van Kunsten en Wetenschappen; Anthropologische Gesellschaft, Vienna; Berliner Gesellschaft für Anthropologie, Ethnologie und Urgeschichte; Astronomische Nachrichten, Kiel; R. Società Italiana D'Igiene, Milan; Société de Geographie, Paris; Société de Borda, Dax; R. Academia de la Historia, Madrid; R. Geographical Society, London; Geological Society of Glasgow; Prof. Daniel Wilson, Toronto; Brooklyn Entomological Society; Mr. William J. Potts, Camden; College of Pharmacy, Prof. E. D. Cope, Dr. D. G. Brinton, Messrs. Henry Phillips, Jr., and William S. Baker, Philadelphia; Johns Hopkins University, Baltimore; Census Office and U. S. Coast and Geodetic Survey, Bureau of Education, Washington; Rev. Stephen D. Peet, Chicago; Observatorio Astronómico Nacional de Tacubaya, Mexico.

This being the evening for the selection of the Standing Committees to serve for the ensuing year, on motion, the President was authorized to appoint the same and to report his action at the next stated meeting of the Society.

This being the evening for the election of a member to serve as Librarian for the ensuing year, a ballot was gone into and on the votes given being counted by the Tellers, it was announced that Mr. Henry Phillips, Jr., had received 61 votes, and Admiral E. Y. McCauley 25, and one vote blank, and Mr. Henry Phillips, Jr., was declared duly elected Librarian for the ensuing year.

Nominations Nos. 1151 and 1152, and new nomination No. 1153, were read.

At this point Vice-Pres. Dr. Ruschenberger took the Chair.

The Committee on the Library presented a report, accompanied with the following resolution, which was adopted:

Resolved, That this Society do appropriate the sum of $100 as a subscription for one series of plates of E. Muybridge's work on *Animal Locomotion;*

the said plates to be selected by him, and the selection to be approved by a Committee to be appointed by the President of this Society.

The Committee on the Michaux legacy presented a report, accompanied by the following resolution, which was adopted:

Resolved, That the sum of $280 be expended under the supervision of the Michaux Committee to enable Dr. J. T. Rothrock to secure a collection of photographic plates of the unique flora of Florida, which may be used as lantern slides to illustrate the course of lectures to be delivered this year in the Park under the auspices of the Society.

And the meeting was adjourned by the presiding member.

Stated Meeting, February 4, 1887.

Present, 12 members.

Vice-President, Dr. RUSCHENBERGER, in the Chair.

Correspondence was read as follows:

Letters of envoy from the Mining Department, Melbourne, Australia; La Société de Borda, Dax, France; The U. S. Geological Survey, Washington, D. C.

La Société Liégeoise de Littérature Wallone, Liege, and La Société des Antiquaries de la Morinie, St. Omer, France, were placed on the exchange list to receive Proceedings from No. 119; K. Meteorologisches Institut, Berlin, Preussen; Physikalische-Medicinische Societät zu Erlangen.

Letters of acknowledgment were read for No. 123 from J. Steenstrup (Copenhagen); Het Bataafsch Genootschap der Proefondervindelijke Wijsbegeerte, Rotterdam; La Société Royale de Zoologie de Amsterdam; Musée Teyler, Harlem; Victoria Institute, London; Cambridge Philosophical Society; for No. 124 from Museum Comp. Zoölogy, Cambridge, Mass.; Mr. L. A. Scott, Philadelphia; Prof. J. H. C. Coffin, the U. S. Geological Survey, and the Smithsonian Institution, Washington, D. C.; Prof. Serge Nikitin, St. Petersburg, 121.

A letter was read from the College of Physicians thanking the Society for the loan of portraits at the late Centennial Celebration of the College.

A letter was read from G. Eichler, in Berlin, in reference to his reproductions from the antique.

Also one from the Buffalo Library inviting the Society to the opening of its new Building, on February 7th, 1887.

Accessions to the Library were received from the Department of Mines, Melbourne; K. K. Geologische Reichsanstalt, Wien; Gartenbauverein zu Darmstadt; Naturwissenschaftliche Gesellschaft "Isis," Dresden; Verein für Thüringische Geschichte, Jena; Astronomische Nachrichten, Kiel; K. Sächsische Gesellschaft der Wissenschaften, Zoologischer Anzeiger, Leipzig; Deutsche Gesellschaft für Anthropologie, Ethnologie und Urgeschichte, München; Prof. E. Renevier, Lausanne; Nordisk Oldkyndeghed og Historie, Copenhagen; Biblioteca N. Centrale, Vittorio Emanuelle, di Roma; Biblioteca N. Centrale di Firenze; Académie des Sciences, Arts and Belles-Lettres de Caen; Société de Borda, Dax; Sociétés de Geographie, de L'Enseignement, D'Anthropologie, D'Ethnographie, and Société Americain de France, Paris; Société des Antiquaires de la Morinie, St. Omer; Royal Society, Society of Arts, Meteorological Office, "Nature," London; Cambridge (Eng.) Philosophical Society; Boston Society of Natural History; Essex Institute, Salem; American Oriental Society, Cambridge; Publishers of "The Travelers' Record," Hartford; American Journal of Science, New Haven; New York Meteorological Observatory; Mr. Wm. John Potts, Camden; Prof. George H. Cook, New Brunswick; Franklin Institute, Pharmaceutical Association, Mercantile and Philadelphia Libraries, Dr. D. Jayne & Son, Henry Phillips, Jr., Philadelphia; Wyoming Historical and Geological Society, Wilkes-Barre; Johns Hopkins University, Prof. Ira Remsen, Baltimore; the Philosophical Society, the U. S. Geological Survey, and John H. Hickcox, Washington, D. C.; Mr. Charles C. Jones, Jr., Augusta, Ga.; the State Historical Society, Iowa City, Iowa; the Imperial Observatory of Rio de Janeiro.

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A communication entitled "An Egyptian Ecclesiastes," by Dr. George Selikovitch, was read by the Secretaries; also one by Dr. Earl Flint, of Rivas, Nicaragua, "On the fossil human foot-prints lately discovered in the *tufa* of Nicaragua." Also one by S. N. Clevenger, of Chicago, entitled "Suggestions concerning the nature of comets."

Dr. Persifor Frazer mentioned the occurrence of a crystallized garnet in a garnet schist in a specimen brought from the Stikine river and presented to him, stating that the matrix was similar to that in which garnet was found near this city.

Pending nominations Nos. 1151, 1152, 1153, and new nominations Nos. 1154, 1155, 1156 were read.

The President reported that according to the request of the Society at its last meeting he had appointed the following to serve as the Standing Committees of the Society for the year 1887:

Finance,

Henry Winsor, J. Price Wetherill, William B. Rogers.

Publication,

Daniel G. Brinton, George H. Horn, Persifor Frazer, J. Blodgett Britton, J. Cheston Morris.

Hall,

J. Sergeant Price, William A. Ingham, Harrison Allen.

Library,

Edwin J. Houston, William V. McKean, Thomas H. Dudley, Francis Jordan, Jr., Edwin A. Barber.

The President reported that he had received and paid over to the Treasurer the sum of $132.12, being the amount of interest on the Michaux Legacy, due January, 1887.

On motion the Library Committee was requested to examine into the desirability of a subscription by the Society to the International Geological Map of Europe; and the Society was adjourned by the presiding officer.

Stated Meeting, February 18, 1887.

Present, 14 members.

Vice-President, Dr. PUSCHENBERGER, in the Chair.

Dr. Charles S. Dolley, a newly-elected member, was presented to the Chair and took his seat.

Correspondence was submitted as follows :

Letters acknowledging election to membership from Dr. A. Réville, Paris; Lucien Adam, Rennes; Vicomte Hyacinthe de Charency, St. Maurice-les-Charency, France; Dr. Conrad Lemanns, Leyden; Sir Henry Sumner Maine, London; Dr. Friederich Mueller, Wien; Dr. Julius Platzmann, Leipzig; Dr. Gustav Weil, Heidelberg; Dr. Henri Kiepert, Berlin; Bishop Crescencio Carrillo, Merida, Yucatan; Dr. A. Bastian, Berlin; Dr. Paul Hunfalvy, Buda-Pesth; Dr. M. Much, Vienna.

Letters of acknowledgment were read as follows:

Kong. Danske Videnskabernes Selskab, Copenhagen (122, 123 and list of members); Dr. E. Suess, Vienna (121, 122, 123, &c.); Oneida Historical Society, Utica, N. Y. (124); Kansas State Historical Society (124); Boston Public Library (124); Maryland Historical Society (124); Lackawanna Institute of Science (124); Royal Society of Tasmania (120); Physikalische Gesellschaft, Berlin (123); K. Meteorologisches Institut, Berlin (123).

Letters of envoy were read as follows: United States Geological Survey, Washington, D. C.

A circular was received from the Trustees of the Elizabeth Thompson Fund stating that the income was again available for appropriations in aid of scientific work; that applications for the same should be made to Dr. C. S. Minot, Boston, Mass.

Accessions to the Library were announced from the following:

Astronomische Nachrichten, Kiel; Zoologischer Anzeiger, Leipzig; Der Naturforscher, Tübingen; K. Statistika Central Byrån, Stockholm; Musée R. d'Histoire Naturelle de Belgique, Bruxelles; R. Società Italiana D'Igiene, Milan;

Société de Géographie, Paris; Royal Society, "Nature," Benjamin Ward Richardson, M. D., London; Geological and Natural History Survey of Canada, Montreal; Rev. Edward E. Hale, Boston; Harvard University, Edward C. Pickering, Cambridge; Prof. James D. Dana, New Haven; Astor Library, New York; College of Pharmacy, Historical Society of Pennsylvania, Messrs. A. E. Foote, Philip H. Law, Henry Phillips, Jr., Philadelphia; War Department, Department of State, U. S. National Museum, Hydrographic Office, U. S. Geological Survey, Washington; Cincinnati Society of Natural History; State Historical Society of Wisconsin, Madison; Minnesota Historical Society, St. Paul.

This being the Stated Meeting for the balloting for candidates for membership, an election was held and the following declared duly elected members of the Society:

No. 2134. John S. Billings, M.D., LL.D., Washington, D. C.

No. 2135. Henry F. Osborn, Professor of Geology, Princeton, New Jersey.

Pending nominations Nos. 1154, 1155 and 1156 and new nominations Nos. 1157 and 1158 were read.

Dr. Harrison Allen made a verbal communication on "Muscular Anomalies in the Subject of an Idiot."

The Minutes of the Board of Officers and Council were submitted.

The Board recommended that the Society should abandon the quarterly issue of its Proceedings and return to the original half-yearly publication.

The Board recommended that the principal of the Michaux legacy should be invested in American securities.

And on motion the meeting was adjourned.

Stated Meeting, March 4, 1887.

Present, 26 members.

President, Mr. FRALEY, in the Chair.

Prof. John F. Ryder, a newly-elected member, was presented to the Chair and took his seat.

Letters were read, accepting membership, as follows: Dr. John S. Billings, Washington, D. C.; Prof. Henry F. Osborn, Princeton, N. J.; Sir Monier Monier-Williams, London; Remi Simeon, Paris; Prof. Paul Topinard, Paris.

Accessions to the Library were announced from Gesellschaft für Erdkunde, R. Friedlander & Sohn, Berlin; Gartenbauverein, Darmstadt; Verein für Erdkunde, Halle a/s.; Deutsche Gesellschaft für Anthropologie, Ethnologie und Urgeschichte, München; Académie R. de Copenhague; Société R. des Sciences de Liege; Musée R. d'Histoire Naturelle de Belgique, Bruxelles; R. Accademia dei Lincei, Rome; Sociétés de L'Enseignement et de Geographie, Ecole des Mines, Paris; R. Academia de la Historia, Madrid; Royal Society, R. Astronomical and Geographical Societies, Meteorological Council, London; Philological Society, Cambridge, England; American Antiquarian Society, Worcester; American Journal of Science, New Haven; Brooklyn Entomological Society; Warner Observatory, Rochester; Mr. Thomas H. Dudley, Camden; Numismatic and Antiquarian Society, Dr. William F. Norris, Dr. F. A. Genth, and Henry Phillips, Jr., Philadelphia; Department of State, U. S. Geological Survey, U. S. National Museum, U. S. Fish Commission, Smithsonian Institution, Washington, D. C.; University of California, Sacramento.

The President presented a communication for the Magellanic Premium, "On the correct determination of the Moon's mass," signed "*Baboika*," which was read and referred to Council.

Pending nominations Nos. 1154, 1155, 1156, 1157 and 1158 were read. The recommendations of Council, submitted at the last meeting, were taken up and considered.

On motion it was resolved to discontinue the quarterly publication of the Proceedings of the Society and to return to the former method of semi-annual issue.

On motion it was resolved to sell the principal of the Michaux legacy, now invested in French *Rentes*, and to cause the proceeds of such sale to be remitted to this country, and

that the Finance Committee and the Treasurer be directed to take all the steps necessary to sell the same whenever such sale shall be deemed expedient and advisable by them; and further that they shall invest the same in good American securities and that the Officers of the Society be empowered to execute all necessary documents and to comply with all requisite formalities.

And the meeting was adjourned by the President.

Stated Meeting, March 18, 1887.

Present, 14 members.

President, Mr. FRALEY, in the Chair.

A letter was read from Columbia College, New York city, New York, inviting the Society to be present by delegate at its approaching Centennial anniversary, April 13, 1887, and the President was empowered to appoint a suitable person to represent the Society.

Letters of envoy were received from the K. P. Meteorologisches Institut, Berlin; Physikalisch-Medizinische Societät, Erlangen; Meteorological Office, Statistical Society, London; Bureau of the Mint, Washington.

Accessions to the Library were reported from the Royal Society of New South Wales, Sydney; K. Akademie der Wissenschaften, Verein zur Beförderung des Gartenbaues in den K. Preussischen Staaten, Physikalische Gesellschaft, K. P. Meteorologisches Institut, Berlin; Physikalisch-Medizinische Societät, Erlangen; K. Nordiske Oldskrift, Selskab, Copenhagen; Institut Royal Grand-Ducal de Luxembourg; Academie Royale de Belgique, Bruxelles; R. Accademia dei Lincei, Rome; Biblioteca N. C. di Firenze; Société de Geographie, Paris; R. Geographical Society, Statistical Society, Meteorological Council, "Nature," London; Philosophical Society of Glasgow; Manitoba Historical and Scientific Society, Winnipeg Board of Trade, Mr. Charles N. Bell, Winnipeg; Museum of Comparative Zoölogy, Cambridge; Meriden Scientific Association; Wesleyan

University, Middletown; Connecticut Academy of Arts and Sciences, New Haven; Editor of "The Critic," New York; Natural History Society, Trenton; Academy of Natural Sciences, College of Pharmacy, Editors of "The American Naturalist," Messrs. H. H. Furness, H. Carvill Lewis, Henry Phillips, Jr., Philadelphia; Gov. James A. Beaver, Harrisburg; Johns Hopkins University, American Journal of Archæology, American Journal of Philology, Baltimore; Light-House Board, Census Office, United States Coast and Geodetic Survey, Bureau of the Mint, Washington; Mr. Jed. Hotchkiss, Staunton; Minnesota Historical Society, St. Paul.

The following papers were presented for the Proceedings:

By Dr. F. A. Genth. "Contributions from the Chemical Laboratory of the University of Pennsylvania. No. XXIX. Contributions to Mineralogy."

Through the Secretaries:

From Prof. John J. Stevenson—"A Geological Reconnaissance of Bland, Giles, Wythe, and portions of Pulaski and Montgomery counties of Virginia."

From Prof. E. D. Cope, on "The Reptilian Fauna of the Mato Grosso, Central Brazil."

Pending nominations Nos. 1154–58 and new nomination No. 1159 were read, and the meeting was adjourned by the President.

Stated Meeting, April 1, 1887.

Present, 16 members.

President, Mr. FRALEY, in the Chair.

A letter of envoy was read from the Meteorological Office, London.

Letters of acknowledgment were read from the K. Zoolog. Genootschap, Amsterdam (124); the Royal Society, Edinburgh (122).

A letter was read from "*Baboika*," requesting the return of a communication under that name for the Magellanic premium, which was on motion ordered to be returned to the

writer. A letter was read from M. J. Thore, of Dax, France, accompanying his pamphlet, entitled "*Une Nouvelle Force?*"

A photograph for the Society's Album was received from Prof. J. W. Moore, of Easton, Pa.

Accessions to the Library were announced from Geological Survey of India, Calcutta; Gartenbauverein, Darmstadt; Astronomische Nachrichten, Kiel; Zoologischer Anzeiger, Leipzig; "Der Naturforscher," Tübingen; Société Hollandaise des Sciences à Harlem; Biblioteca N. C. di Firenze Societé Toscana di Scienze Naturali, Pisa; R. Accademia dè Lincei, Rome; Société de Borda and Mr. J. Thore, Dax; Sociétés de Geographie, de L'Enseignement and publisher of the Revue de L'Enseignement Secondaire et Supérieur, Paris; Sociedade de Geographia, Academia R. das Sciencias, Lisbon; Royal Society, Geological Society, Royal Astronomical Society, Meteorological Council, "Nature," and "The Earth," London; Cambridge Philological Society; Bath and West of England Society; Natural History Transactions of Northumberland, Durham and New Castle on Tyne; publisher of the "Travelers' Record," Hartford; Brooklyn Entomological Society; Franklin Institute, Engineers' Club, Journal of Medical Sciences, Mercantile Library Co., publisher of the "American Naturalist," and Mr. Henry Phillips, Jr., Philadelphia; Germantown Dispensary and Hospital; Johns Hopkins University, Prof. Ira Remsen, Baltimore; Bureau of Education, Department of State, Washington, D. C.; Rev. Stephen D. Peet, and the publisher of "The Open Court," Chicago; Observatorio Meteorologico Magnetico Central, Mexico.

The Secretaries presented a communication from Prof. E. W. Claypole, Akron, Ohio, entitled "On Organic Variation, indefinite not definite in direction, an outcome of environment."

Prof. Barker made a communication on the methods and discoveries of Prof. Pickering in Astronomical Physics, based upon his researches with the Bache and Draper funds, and exhibited spectra of the stars *a Cygni* and *a Tauri*, on which some remarks were made by Dr. Frazer.

Pending nominations Nos. 1154–59, and new nominations Nos. 1160–66, were read.

Dr. D. G. Brinton offered the following resolution: "That after action on the candidates now proposed for membership, the resident members shall be limited to 150 persons."

Dr. Frazer offered as an amendment: "That a Committee of scrutineers be elected as a permanent committee of the Society, of which the duty shall be to examine the qualifications of all candidates for membership and report upon the same to the Society, and no vote shall be taken on candidates by the Society, until the presentation of a report on their qualifications by the scrutineers."

At the suggestion of the President, the motions were withdrawn, and Dr. Brinton offered the following substitute, which was unanimously adopted: "Resolved that the President be authorized to appoint at his leisure a committee of five members to consider these resolutions and the whole subject of the restriction of membership in the Society, and to report its action to the Society.*

Prof. Barker stated that he had received from Prof. G. A. Hirn, of Colmar, a letter accepting membership in the Society, and thanking it for the honor conferred.

And the Society was adjourned by the President.

Stated Meeting, April 15, 1887.

Present, 15 members.

Mr. THOMAS H. DUDLEY in the Chair.

Correspondence was submitted as follows: A circular from the Académie des Sciences, Arts et Belles-Lettres, Dijon, announcing the awarding of prizes.

Envoys from the Physikalische Central Observatorium, St. Petersburg; K. Preuss. Geologische Landesanstalt u. Berga-

*On April 4. the President appointed Dr. D. G. Brinton, Chairman; Dr. Frazer, Dr. Wm. Thomson, Dr. Goodwin and Mr. Ingham as the committee.

cademie (Berlin), and requesting exchanges;* R. Geographical Society, London; Col. Garrick Mallery, Washington, D. C.

Acknowledgments from the Comité Géologique, St. Petersburg (122); Anthropologische Gesellschaft, Berlin (96–124); Verein für Thüringische Geschichte und Alterthumskunde, Jena (96–110, 112–124); Fondation de P. Teyler Harlem (124); Bataafsch Genootschap van Proefondervindelijke Wijsbegeerte, Rotterdam (124); Société R. des Sciences, Liège (124), and asks for (100);† Société D' Emulation d'Abbeville (124); Société Historique Artistique et Scientifique, du Cher (119); Cambridge Philosophical Society and University Library, Cambridge, England (124); Royal Institution, Society of Antiquaries and Sir Richard Owen, Royal Horticultural Society, London (124).

Accessions to the Library were received from the Geological Survey of India, Calcutta; Société Impériale des Naturalistes, Moscow; Natural History Society, Odessa; Comité Géologique, Physikalische Central Observatorium, St. Petersburg; R. Friedlander and Sohn, Berlin; Astronomische Nachrichten, Kiel; Zoologischer Anzeiger, Leipzig; Dr. F. v. Sandberger, Würtzburg; Académie R. de Belgique, Bruxelles; R. Società Italiana D'Igiene, Milan; Biblioteca, N. C. V. E., Rome; R. Academia de la Historia, Madrid; Royal Society, R. Geographical Society, R. Meteorological Society, Meteorological Council, "Nature," London; Rousdon Observatory, Devon; Philosophical Society, Cambridge (England); Massachusetts Historical Society, Boston; Museum of Comparative Zoölogy, Cambridge; Free Public Library, New Bedford; Providence Public Library; publishers of the "Travelers' Record," Hartford; American Journal of Science, New Haven; Brooklyn Entomological Society, American Chemical Society, Meteorological Observatory, New York; Historical Society of Pennsylvania, College of Pharmacy, publishers of "The American Naturalist" and "Naturalists' Leisure Hour," Henry Phillips, Jr., Philadelphia; Johns Hopkins University, Baltimore; Hydrographic Office, Garrick Mallery, Washington, D. C.

* Ordered to receive from 96.
† Ordered to be sent.

Elliott Society and Art, Charleston; Wm. Harden, Savannah; Cincinnati Society of Natural History.

A paper for the Transactions by Joseph L. Hancock, of Chicago, on the Datames Magna, was presented and referred to a committee to be appointed by the President.

The following communications were offered (through the Secretaries) for the Proceedings: "On the medical mythology of Ireland," by Mr. James Mooney, Bureau of Ethnology, Washington, D.C.; "On the relation of Aerolites to Shooting Stars," by Prof. Daniel Kirkwood, Bloomington, Indiana; "On the Triassic mammals Dromatherium and Microconodon," by Prof. H. Osborn, Princeton, N. J.

Prof. Cope made a communication "On the Vertebrata of the Trias of New Mexico," which he illustrated by specimens.

Pending nominations Nos. 1154–1166, and new nominations Nos. 1167, 1168, were read.

The Trustees of Building Fund presented their annual report.

A communication was presented from Dr. Brinton, Chairman of the Special Committee, appointed at the last meeting, reporting progress, and on motion the committee was continued.

And the Society was adjourned by the presiding member.

Stated Meeting, May 6th, 1887.

Present, 13 members.

President, Mr. FRALEY, in the Chair.

Correspondence was submitted as follows: Letters of envoy from Department of Mines, Wellington, New Zealand; Hong Kong Observatory; Institut Météorologique de Roumanie, Bucharest; Maatschappij der Nederlandsche Letterkunde te Leiden; Bureau des Longitudes, Paris; Meteorological Office, London; Literary and Philosophical Society of Liverpool.

Letters of acknowledgment from The Royal Society of New South Wales (122); Comité Géologique de la Russie, St. Petersburg (124); Prof. Serge Nikitin, St. Petersburg (124);

Société des Antiquaires de la Morinie, Saint Omer (121, 122, 123), and Register, etc.

A letter was read from Dr. Genth in reference to an addition to his paper on Pseudo-maple Mimetites.

Accessions to the library were reported from the Department of Mines, Wellington, New Zealand; Hong Kong Observatory; K. Akademie der Wissenschaften; Comité Géologique, St. Petersburg; Institut Météorologique de Roumanie, Bucharest; K. K. Zoologisch-Botanische and Geographische Gesellschaften, K. K. Geologische Reichsanstalt, Vienna; Hungarian Academy, Budapest; K. Preussischen Akademie der Wissenschaften, Deutsche Geologische Gesellschaft, and R. Friedlander & Sohn, Berlin; Prof. G. vom Rath, Bonn; Gartenbauverein zu Darmstadt; Naturwissenschaftliche Gesellschaft "Isis," Dresden; Oberlausitzer Gesellschaft der Wissenschaften, Görlitz; Deutsche Gesellschaft für Anthropologie, Ethnologie, etc., München; Voigtländ. Verein für Naturkunde, Reichenbach; Maatschappij der Nederlandsche Letterkunde, Flora Batava, Leiden; Musée R. d'Histoire Naturelle de Belgique, Bruxelles; Naturwissenschaftliche Gesellschaft, St. Gallen; R. Accademie dei Lincei, Rome; Société Linnéenne de Bordeaux; Musée Guimet, Institution Ethnographique, Bureau des Longitudes, Sociétés de l'Enseignement superieur, Zoologique, Marquis de Nadaillac, Paris; Société des Antiquaires de la Morinie, Saint Omer; Literary and Philosophical Society, Liverpool; R. Astronomical Society, Meteorological Council, Diplomatic Review Office, Rev. E. W. Syle, London; Yorkshire Geological and Polytechnic Society, Halifax (England); Natural History Society, Montreal; The Canadian Institute, Toronto; Astronomical Observatory of Harvard College, Prof. Eben Norton Horsford, Cambridge; Massachusetts Historical Society, Boston; American Journal of Science, New Haven; Academy of Sciences, Historical Society, "The Forum" Publishing Co., Prof. John J. Stevenson, New York; Secretary of Internal Affairs, Harrisburg; Johns Hopkins University, Baltimore; United States National Museum, Hydrographic Office, Washington (D. C.); University of Virginia; Scientific Association of Peoria; State Histori-

cal Society, Iowa City; Impereal Observatorio do Rio de Janeiro.

Dr. Horn, from the Committee on the *Datames Magna*, reported progress, and on motion the Committee was continued.

A paper by William Blasius on "The Signal Service Bureau, its methods and results," was presented.

Prof. Cope presented MS. of his communication on the "Vertebrata of the Trias of New Mexico," with a plate.

A communication was presented for the Magellanic premium, signed "Magellan," which was referred to Council.

Pending nominations 1154 to 1168 and new nomination 1169 were read.

Dr. Brinton, chairman of the Committee appointed April 1, 1887, presented a report, and the Committee was on motion discharged.

The President reported receipt and payment to the Treasurer of $132.43, interest on the Michaux legacy.

Notice having been given to the members that the Society would consider the subject of the sale of the French *Rentes*, constituting the corpus of the Michaux legacy, the subject was taken up and the President informed the Society that he had handed to Drexel, Harjes & Co., of Paris, an attested copy of the resolution adopted on March 14, 1887, for the sale of the said Rentes, and one of the forms of sale and transfer used here for selling and transferring stocks and loans and inquired whether the sale could be made in that way, and that he had also sent to them a copy of the laws of this Society. In reply they had sent a letter indicating what they by inquiry had found to be deemed necessary, which letter was then read to the Society.

The President then stated that he had prepared the following resolutions in order to meet the views suggested in said letter, and submitted them for the action of the Society thereon, as follows:

"*Resolved*, That the Society authorizes the sale of certificates of 2778 Rentes, French 3 per cent, which the American Philosophical Society possesses in its name upon the books of

the French Public Debt No. 279,732 of Seriè 7, coming from the Michaux legacy.

"*Resolved*, That Frederick Fraley, President, and J. Sergeant Price, Treasurer, of the American Philosophical Society, be and they are hereby authorized and empowered to make, execute and deliver under the corporate seal of the Society a power of attorney in legal form constituting John H. Harjes, of the firm of Drexel, Harjes & Co., Paris, France, the attorney of said Society to sell, assign and transfer to any purchaser thereof, the 2778 francs French three per cent *Rentes* described in the foregoing resolution, and to do all matters and things legally necessary for the sale, transfer and assignment of the said *Rentes* that may be required by the French Treasury."

The resolutions were seconded by Dr. Ruschenberger, and after due consideration were unanimously agreed to and further action thereon was ordered to be made part of the stated business of the meeting of the Society to be held on May 20th, 1887, of which due notice shall be given to the members.

And the Society was adjourned by the President.

Stated Meeting, May 20, 1887.

Present, 38 members.

President, Mr. FRALEY, in the Chair.

Dr. W. H. Wahl was presented to the Chair and took his seat.

Correspondence was submitted as follows: Envoys, from the Hong Kong Observatory; Geological Survey of India; Naturforschende Verein in Brünn; K. Sachsischer Alterthums-Verein, Dresden; Meteorological Office, London; Department of the Interior, Washington, D. C.

Letters of acknowledgment from the South African Philosophical Society, Cape Town (96–123 and Register, etc.); Prof. J. J. Steenstrup, Copenhagen (124); Observatorio Astronomico Nacional Mexicano (123).

Accessions to the Library were received from the Hong Kong Observatory; China Branch of the R. Asiatic Society,

Shanghai; The Great Trigonometrical Survey of India, Dehra Dun; K. Russische Geographische Gesellschaft, St. Petersburg; Anthropologische Gesellschaft, Wien; Gesellschaft für Anthropologie, Ethnologie, &c., K. Preussische Geologische Landesanstalt und Bergakademie, Gesellschaft für Erdkunde, Berlin; Naturforschende Verein in Brünn; Gartenbauverein zu Darmstadt; Sachsische Geschichte und Alterthumskunde Verein, Dresden; Prof. Dr. Paul Albrecht, Hamburg; K. Sachsische Gesellschaft der Wissenschaften, L. Fernan (publisher), Leipzig; Verein für Erdkunde, Stettin; Société Hollandaise des Sciences à Harlem; Académie R. de Belgique, Bruxelles; Biblioteca N. C. di Firenze; R. Società Italiana D'Igiene, Milan; R. Accademia dei Lincei, Rome; Société Americaine de France, Société de Geographie, Paris; R. Accademia de la Historia, Madrid; Meteorological Council, Nature, London; Nova Scotia Institute of Natural Sciences, Halifax; Harvard University, Cambridge; Rhode Island Historical Society, Providence; Buffalo Library; American Chemical Society, publisher of "The Public Service Review," Prof. Samuel Lockwood, New York; College of Pharmacy, Zoölogical Society, Philadelphia; Prof. Ira Remsen, Baltimore; U. S. Naval Institute, Annapolis; U. S. Geological Survey, Department of Agriculture, Washington, D. C.

Dr. Horn, from the Committee on the "Datames Magna," reported progress, and on motion the committee was continued.

The following deaths were announced: Prof. Bernard Studer, Berne, May 2, 1887, in his 93d year; John T. Napier, Rothesay, Scotland, May, 1887, in his 29th.

On motion the President was authorized to appoint a suitable person to prepare the usual obituary notice of Mr. Napier.

The minutes of the Board of Officers and Council were submitted.

On motion the President was authorized to appoint at his leisure a committee of five (5) members to examine the communication signed "Magellan," submitted for the Magellanic premium, and to report to Council as to its merits.

Notice having been given to the members that the Society would take a final action upon the question of the sale of the French *Rentes*, constituting the Michaux legacy, the same was taken up as the stated business of the meeting and considered, and the resolution passed at the last stated meeting of the Society was again put to the vote and unanimously adopted.

This being the stated meeting for balloting for members an election was gone into, and after scrutiny, by the tellers, of the votes given, the following were declared to have been duly elected members of the Society:

No. 2136. Mr. Joseph S. Harris, Philadelphia.
No. 2137. Dr. William Powell Wilson, Philadelphia.
No. 2138. Dr. James Tyson, Philadelphia.
No. 2139. Mr. William Henry Rawle, Philadelphia.
No. 2140. Mr. Henry D. Wireman, Philadelphia.
No. 2141. Prof. Albert H. Smyth, Philadelphia.
No. 2142. Miss Helen C. de S. Abbott, Philadelphia.
No. 2143. Mr. Henry H. Houston, Philadelphia.
No. 2144. Prof. William T. Barnard, Baltimore.

Pending nominations Nos. 1156, 1159 and 1164 were on motion deferred until the next regular meeting for the balloting for candidates.

Pending nomination No. 1169 and new nomination No. 1170 were read.

A paper was presented, through the Secretaries, by Prof. John J. Stevenson, "Notes on the Surface Geology of Southwest Virginia."

A letter was read from Dr. Frazer in reference to the discharge, at the last meeting, of the committee appointed April 1st, asking that "the action of the Society be recalled."

Dr. J. Cheston Morris moved "that the resolution of the Society adopted at the last meeting discharging the said committee be reconsidered."

The motion was seconded and after discussion being put to a vote, the yeas were 15 and nays 20, and the Society refused to reconsider the said motion.

And the Society was adjourned by the President.

him the communication, description, or model, except the officer to whom it shall be entrusted; nor shall such officer part with the same out of his custody, without a special order of the Society for that purpose.

6. The Society, having previously referred the several communications from candidates for the premium, then depending, to the consideration of the twelve counsellors and other officers of the Society, and having received their report thereon, shall, at one of their stated meetings in the month of December, annually, after the expiration of this current year (of the time and place, together with the particular occasion of which meeting due notice shall be previously given, by public advertisement) proceed to final adjudication of the said premium; and, after due consideration had, a vote shall first be taken on this question, viz.: Whether any of the communications then under inspection be worthy of the proposed premium? If this question be determined in the negative, the whole business shall be deferred till another year; but if in the affirmative, the Society shall proceed to determine by ballot, given by the members at large, the discovery, invention or improvement most useful and worthy; and that discovery, invention, or improvement which shall be found to have a majority of concurring votes in its favor shall be successful; and then, and not till then, the sealed letter accompanying the crowned performance shall be opened, and the name of the author announced as the person entitled to the said premium.

7. No member of the Society who is a candidate for the premium then depending, or who hath not previously declared to the Society, that he has considered and weighed, according to the best of his judgment, the comparative merits of the several claims then under consideration, shall sit in judgment, or give his vote in awarding the said premium.

8. A full account of the crowned subject shall be published by the Society, as soon as may be after the adjudication, either in a separate publication, or in the next succeeding volume of their Transactions, or in both.

9. The unsuccessful performances shall remain under consideration, and their authors be considered as candidates for the premium for five years next succeeding the time of their presentment; except such performances as their authors may, in the meantime, think fit to withdraw. And the Society shall annually publish an abstract of the titles, object, or subject matter of the communications, so under consideration; such only excepted as the Society shall think not worthy of public notice.

10. The letters containing the names of authors whose performances shall be rejected, or which shall be found unsuccessful after a trial of five years, shall be burnt before the Society, without breaking the seals.

11. In case there should be a failure, in any year, of any communication worthy of the proposed premium, there will then be two premiums to be awarded the next year. But no accumulation of premiums

shall entitle the author to more than one premium for any one discovery, invention or improvement.

12. The premium shall consist of an oval plate of solid standard gold of the value of ten guineas. On one side thereof shall be neatly engraved a short Latin motto suited to the occasion, together with the words: "The Premium of John Hyacinth de Magellan, of London, established in the year 1786;" and on the other side of the plate shall be engraved these words: "Awarded by the A. P. S. for the discovery of——A.D.——." And the seal of the Society shall be annexed to the medal by a ribbon passing through a small hole at the lower edge thereof.

SECTION 2. The Magellanic fund of two hundred guineas shall be considered as ten hundred and fifty dollars, and shall be invested separately from the other funds belonging to or under the care of the Society, and a separate and distinct account of it shall be kept by the treasurer.

The said fund shall be credited with the sum of one hundred dollars, to represent the two premiums for which the Society is now liable.

The treasurer shall credit the said fund with the interest received on the investment thereof, and, if any surplus of said interest shall remain after providing for the premiums which may then be demandable, said surplus shall be used by the Society for making publication of the terms of the said premium, and for such purposes as may be authorized by its charter and laws.

The treasurer shall, at the first stated meeting of the Society in the month of December annually, make a report of the state of said fund and of the investment thereof.

☞ Members who have not as yet sent their photographs for the Society's album will confer a favor by so doing.

☞ Please communicate any change of address or inaccuracy in name.

☞ A few sets of the Society's Transactions, New Series, 1818 to 1892, XVI vols., 4to, can be obtained from the Librarian. Price, $80.00.